1960

Selective Reinforcers in the Operant Conditioning of Normal and Exceptional Children

Frank Anthony Dinello
Loyola University Chicago

SELECTIVE REINFORCERS IN THE OPERANT CONDITIONING OF NORMAL AND EXCEPTIONAL CHILDREN

Frank A. Dinello

A Dissertation Submitted to the Faculty of the Graduate School of Loyola University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

September

1960

LIFE

Frank Anthony Dinello was born in Chicago, Illinois, May 28, 1929.

He was graduated from Proviso Township High School, Maywood, Illinois, June, 1947. In February, 1951, he entered the Armed Forces and was honorably discharged in February, 1953.

In June, 1955, he graduated from the University of Illinois with the degree of Bachelor of Science. He received the degree of Master of Arts from Loyola University, Chicago, Illinois, in June, 1958.

Since June, 1955, he has been affiliated with the Loyola Center for Guidance and is presently a member of its staff.

Table of Contents

List of Tables

List of Figures

List of Pictures

Acknowledgements

Expressions of appreciation are due to many individuals whose contributions made this study possible. A special indebtedness is owed Frank J. Kobler, Ph.D., who gave freely of his time and ideas, and who showed constant interest and encouragement. Halmuth H. Schaefer, Ph.D. also made many helpful suggestions and criticisms, and did much of the groundwork with the equipment. Appreciation is also expressed to members of the Loyola Behavior Laboratory staff. Gene Wuest, an electrical engineer, was extremely helpful in the beginning stages of the work. Thanks are also due Ann Dinello for her aid in many areas. The writer also wishes to express his appreciation to the parents and subjects who gave so generously of their time.

Chapter I

Introduction and Purpose

Beginning in 1930 Skinner developed a theory and technique of studying behavior which resulted from observations of animals performing in a type of experiment that he invented. In order to be rewarded or reinforced, the animal first needed to emit the desired behavior. This type of learning or operant conditioning describes the fact that any behavior immediately followed by presentation of reinforcement tends to occur more frequently thereafter. An animal is thus placed in a small enclosure where he is free to make any response at any time. If the animal operates a small lever, or emits any other behavior desired by the experimenter, he is promptly reinforced. Reinforcement refers to the technique of increasing the frequency of an activity by following it with a special consequence. The subject acts and the subsequent frequency of this activity increases because of the past effect on the environment. Through varying the nature and conditions of the reinforcement, complex behaviors have been developed and measured.

Newer andmore complex systems are still being developed which give greater understanding of this system. Presently, "the method", as adherents refer to it, competes favorably with

other learning experimentation such as Hullian formulations and mathematical models. The growth of Skinner's influence appears to be a consequence of the dissatisfaction with the empirical basis of Hull's theory.

In very recent years, experimental techniques have been explored using children and adults as subjects. Many authors feel that this line of research holds great promise. Work has been done and is currently in progress using psychotic adults and children, mentally defective and normal children.

Using animals has certain advantages. Water and food to thirsty and hungry animals tends to elicit desired behavior quickly and maintain it indefinitely. Since this approach is not practical with humans it is necessary to use different reinforcers. Reinforcement given must elicit and maintain interest even though not essential to the subject's comfort or welfare. In many operant conditioning experiments being conducted with children, authors report large satiation effects arising from reinforcers not sufficiently durable.

The primary purpose of this study was to find a reinforcer which may be used over long periods of time with minimal satiation effects. Such a reinforcer should have the necessary versatility to maintain a consistently high interest level.

It is hypothesized that any reinforcer satisfying the above requirements will show a significant superiority in eliciting performance when compared with a reinforcer extensively used by

other experimenters.

A secondary purpose of this study was to investigate the free operant conditioning technique developed by Skinner and others as a means of observing and analyzing the behavior of normal and retarded children. It is hoped that increased knowledge in this area will provide additional means for training and teaching young children.

Chapter II

Review of the Literature

Over the past sixty years the development of measuring devices has shown a consistent trend toward simplicity of design and automatic control. In 1938 Skinner (25) described an instrument which had the properties of simplicity of design and analysis, and which, at the same time, was appropriate for the study of almost all types of operant or "volitional" behavior. Some authors have called it the "Skinner box", although similar devices had been used by the Russians many years earlier. The enclosure, of course, is not necessarily a box; it could be a room, aquarium or an aviary.

There are many articles published which investigate and study operant techniques with animal subjects such as rats, pigeons, octopi and even, in recent years, with human subjects. The following studies are directly or indirectly related to this research.

The pioneering work with human beings was begun using psychotic adults as subjects. Skinner (22) first reported his work on the experimental analysis of the behavior of psychotic patients in 1954. Each patient was left alone one hour per day in a small room containing a device similar to a vending machine.

The patient was able to operate the plunger on the machine and this behavior was reinforced with candy, cigarettes, or short exposures of interesting pictures. The rate at which the machine was operated was studied. The technique produced sustained responding for one hour each day for many weeks in the fifteen patients studied. Diagnoses of the subjects included catatonics, mental defectives with delusion, paranoids and, in one case, a manic. The response rates ranged from almost zero in the case of the catatonics to 10,000 responses per hour in the case of the manic subject. While the sample was too small for any general conclusions, the experiments showed conclusively that the general method could be used with psychotic subjects. The records obtained provided an excellent base line for observing the moment to moment effects of drugs or the effects of other forms of therapy. The method is thought by the author to be adaptable to social situations in which cooperative or competitive behavior can be established. The long-range aim or the experimentation was to gain "control" of the patient and influence him to perform in ways deemed more acceptable.

Skinner's work raises questions and suggests several possibilities: (1) If the time of the sessions were lengthened, would the ratio of non-psychotic behavior to psychotic behavior hold up with the consequence that greater and greater parts of each day would be spent in organized activity? (2) Would there be extensive transfer effects to other tasks and other situations? If so, then a real therapeutic outcome could be anticipated.

The above work was carried forward during the period from December, 1954, to June, 1956, and reported by project directors Skinner, Solomon and Lindsley (14). One year was spent in designing, constructing and equipping five new experimental rooms. Each room contained a chair, ash tray, and the standard manipulandum panel that was developed for experimentation with human subjects.

Until this experimentation the only clinical measures available about the patients were their admission I.Q.'s, admission diagnoses, and the periodic psychiatric evaluations entered in the patients' case histories. On the basis of this research the authors suggested a relationship between the rate of response of chronic psychotics and "severity of illness" or "depth of psychosis". The patients who responded at the very low, erratic rates were from the disturbed wards, were unable to work and were untidy and less able to care for themselves than the patients who responded at high, even rates. The nature of the disturbance (i.e. catatonic, manic, depressed, etc.) did not seem to correlate with the rate of response, but the degree of the disturbance did seem to correlate. However, the authors presented no quantitative measure of this "depth of psychosis". The rate of response correlated positively with the "ability to work" as rated on a ten point scale. Ratings of the patients' verbal behavior and social rapport did not correlate with the rate, neither did the admission I.Q.'s nor the total years of

hospitalization for mental illness. The clinical testing showed that the patients used were representative of the average patients in a large state hospital. Forty-five per cent of the patients who were accessible by operant techniques were unaccessible by clinical tests.

The sample used in the study was not sufficiently large to form general conclusions. However, the research during this period was largely exploratory. The authors had many technical difficulties to overcome and were building the foundation for years of future experimentation. It would have been helpful if the authors would have explained on what basis they measured severity of illness since this seemed the only area which correlated positively with rate of response.

Lindsley (15) further reports on work with psychotics. In two and a half years 4,500 hours of data were collected from 60 psychotic patients. The author's primary purpose was to develop a basic research tool for the measurement of "the simple and complex individual and social behavior of psychotic patients and then to proceed with an analysis of behavior anomalies found in psychosis".

Lindsley reports that several patients showed evidence of clinical improvement since the experimental work was begun. Unfortunately the author does not present this evidence nor does he attempt to analyze the changes which took place. It is not clear from the article that the experimental treatments produced

the changes. In fairness to the author it should be stated that the stress was on methodology rather than results. Since the method was new in 1956 and had not been used elsewhere, it was not designed to produce immediate practical results.

Lindsley lists some disadvantages and advantages of the method. Among the disadvantages he mentions: (1) the considerable time spent in training and stabilization of patients; (2) not applicable for correlations with another measure depending on a large "N" for its reliability since the free operant method probably would take too long to generate such a large sample; (3) the large financial and temporal investments; and (4) the need for skilled technicians to trouble-shoot the controlling and scheduling equipment. As advantages he lists: (1) high experimental control; (2) automatic recording and scheduling; (3) high generality; (4) free operant nature; and (5) lack of instructions. Lindsley is convinced that the method should be considered along with other promising research tools by investigators of chronic schizophrenia.

Skinner, Solomon, and Lindsley (16) reported further research completed during the period from September, 1955, to November, 1956. The authors state that the methodological phase of their research was now completed and the third year was spent full time on the analysis of psychotic behavior. The research covered included over 10,000 patient-hours on 51 adults. One of the most

valuable phases of this work, and one directly related to the present research, was the exploration of useful reinforcers. It was necessary to try many different reinforcers with a group of patients to determine whether the low, erratic rate of some patients was a general characteristic of the psychotics' behavior or if some reinforcer could be found which would produce a high, even rate for each patient. The following reinforcers were used: (1) candy, (2) female nude pictures, (3) male nude pictures, (4) five-cent pieces, and (5) feeding a hungry kitten. The results show that operant rate of response for a wide variety of reinforcers correlates lowly, but significantly, with the adjustment of the patients to the hospital environment. The different reinforcers were evaluated with respect to their relative efficiency in predicting hospital adjustment. Reinforcement with male nude pictures produced the highest and most significant correlations with ward behavior for male patients. Candy also proved to be a very efficient reinforcer. The individual profiles of rates of response for the five different reinforcers showed at least eight significantly different patterns of motivation. These patterns--low altruistic interest (feeding kitten), low sexual interest (female and male nudes), low rate for conditioned reinforcement (five-cent pieces), low candy motivation (candy), and a high extinction rate--are considered by the authors as useful for future diagnosis and research. The individual profiles

presented appeared to be very stable. Alteration was shown to be possible by the administration of certain drugs. Chlorpromazine, for example, sharply reduced the rate of response for male and female nudes without altering the rate for candy reinforcers in two patients. The authors noted, in passing, that the psychiatric diagnoses would have been very poor predictors of the level or profile of motivation recorded from patients.

This research presents a larger sample than past literature and is thoroughly done. The authors revealed conclusive results in their sample which any other experimenter should be able to repeat successfully. Concentration was directed to a few areas with resulting conclusive evidence.

Plans for future work listed: (1) the effects of Ritalin; Serpasil, and Dexedrine; (2) the exploration of useful aversive stimuli such as noise and shock; and (3) the analysis of refusals and withdrawals.

Mednick and Lindsley (19) have carried on the work with psychotics. The authors previously gave intensive study to 51 subjects and reported many individual differences in the rate at which a patient pulls a lever in order to obtain a particular reinforcement. The rate of response, however, is not related to admission diagnosis, intelligent quotient, or total time of hospitalization. The rate of response appears to be directly related to "depth of psychosis or severity of illness". In this

study the authors attempted to examine systematically the relationship of severity of illness to experimental performance in a chronic patient population. Twenty-two male chronic psychotic patients, hospitalized from three to forty-seven years and six male hospital attendants were the subjects used. The S's in this study were reinforced with a mixture of penny candy and cigarettes. The Lucero-Meyer Fergus Falls Behavior Sheet was chosen to rate the ward behavior of the patients. In addition a diagnostic test battery was also given consisting of the short form of the Wechsler-Bellevue, Form I, the Rorschach, and the Tulane Psychological Test Behavior Rating Scale. Three response measures were used in the analysis of the operant conditioning data: the rate of response, the total number of inter-response times greater than 10 seconds (i.e. the total amount of time during which the subject did not respond). Results showed that the untestable patients have few pauses but do not respond for almost the entire hour, while the testable patients take numerous short breaks. Thus it was clearly shown that the two patient groups (testable and untestable) differed from each other as well as from the normals with respect to responsivity and intra-hour variability. The study strongly suggests that the operant conditioning performance of chronic psychotic patients and certain clinical variables are related. The earlier impression of a positive relationship between rate of response and severity

of illness was supported. Those patients who were testable by at least one clinical test were those who were high operant responders.

This is the first study reporting statistical analysis regarding the relationship between rates of operant response and clinical tests. Little information, however, was given concerning the individual tests. It was shown only that testable patients had a significantly higher rate of response than non-testable patients. More information comparing the individual tests such as the Wechsler-Bellevue Intelligence Scale with rate of response would have been desirable. This work does, however, give some indication of what is meant by "severity of illness" and how it was measured.

The last research reported dealing with psychotic behavior and operant conditioning techniques was completed by Ferster (11). This research deals with psychotic children and appears to be the first to use operant techniques for some practical instead of theoretical goal. The authors' contention is that "it might be possible to deal with autistic children experimentally by building a new behavioral repertoire beginning with activities already in the child's repertoire, finding a method of sustaining them, and then gradually widening their range". The paper is intended to describe such a method and the techniques necessary for expanding behavior. Also discussed are techniques for

achieving a more durable reinforcer. The three subjects used in the experiment all showed the common characteristics of an extremely narrow range of behavioral repertoire, disorders in speech, lack of emotional control and rage reactions.

The experimental room contained a large number of devices which when operated either by a coin or direct key provide some rewarding consequence for the child. These devices included a pinball machine; a pigeon and trained monkey; a color wheel; a television set; a phonograph; an electric train; a candy vending machine; a trinket vending machine which also delivered food; a telephone hand set with music through the ear piece; an electric organ; and a 35 mm. slide viewer. Each child "worked" for coins which operated all these devices so that there was a large contribution to the reinforcing effect. The authors showed that it is possible to bring the behavior of the children under the close control of an artificial environment by means of such a generalized reinforcer. Some problem solving was initiated (matching circles, stars, etc.) and the child was reinforced for correct responses. Future studies will attempt to develop and widen such behavior as this and the authors feel this to be feasible under the proper conditions.

While this research appears to be an excellent exploratory study, it would be helpful if more were known about the reinforcers. For instance, one of the devices used for reinforcement was a 35 mm. slide viewer. However, no information is given

regarding the kind of pictures used, how long the child was permitted to view each and how the pictures were chosen. This information wouldhave been particularly valuable in connection with the present study.

Several authors have shown an interest in using operant techniques with children. Bijou has done more work in this particular area than any other experimenter. He has described (3) a laboratory method for the systematic study of the behavior of preschool children. A number of considerations influenced the development of the technique. First, the author believed the method should involve a relatively simple situation, one allowing for considerable control of the experimental variables. Second, it should require the child to make a relatively uncomplicated voluntary response, the frequency of which could be automatically and objectively recorded. Third, it should be adequate to explore problems suggested by laboratory studies with children. The author comments that while experimenters to date have used various reinforcers (party mints, chocolate bits, and plastic balls) no one had yet attempted to determine the relative effectiveness of classes of reinforcers for children at the various developmental stages. From work on several reinforcers (appearance of a toy dog, candy balls, pleasant sounding tones, trinkets, etc.) the author developed an apparatus which delivered a trinket when the subject dropped a ball into a hole. Initial efforts have been devoted to analyzing the

consequences of different schedules of reinforcement and the influence of two auditory stimuli accompanying reinforcement during training.

The device described by Bijou would appear to have many limitations especially with preschool children. As he explains the procedure, a child must take a ball from a receptacle and drop it into a hole after which he may be reinforced. The uncontrolled variations of such a procedure would be many. These would result from balls missing the hole or dropping from the child's hand. In addition, the child might play with the ball and act toward it as if it were the reinforcer. A better procedure might be one that permitted only the reinforcing object to come into the child's hand.

Azrin (1) has done some work involving the cooperation between children. He states his problem as follows: "can cooperation between children be developed, maintained, and eliminated solely by the presentation or non-presentation of a single reinforcing stimulus available to each member of the cooperative team following each cooperative response?". Twenty children aged seven to twelve were formed into ten cooperative teams of two children matched to age and sex. Cooperation was assured by designing an apparatus that, (1) could not be operated by one individual alone, and (2) demanded that one individual respond to the behavior of the other individual in order to produce reinforcement. All teams learned to cooperate in the first ten

minutes of experimentation without specific instruction with candy used as the reinforcer. The authors concluded that operant conditioning techniques could be used to develop, maintain, and eliminate cooperation between children without the use of specific instructions concerning cooperation. The rate of a cooperative response appeared to change in much the same way as a function of single reinforcements as an individual response. In the reinforcement of cooperative responses, a reinforcing stimulus did not need to be delivered to each member of the cooperative team following each cooperative response. Cooperative responses were maintained at a stable rate during reinforcement but occurred in sporadic bursts during extinction. Reinforcement following extinction resulted in an almost immediate restoration of the rate of cooperation to its pre-extinction value.

The cooperation reported in this research is of limited value and simple in scope. However, the results suggest the possibility of increased knowledge of the problem through additional research. Home training, group cooperation and classroom teaching may all be areas which may profit from research of this kind.

Bijou (2) describes several revisions made in the technique reviewed above. In earlier experiments the child dropped a ball into a hole. This technique proved to be satisfactory except for the three seconds which the response took; this meant that many changes in behavior were not being recorded

and the total number of responses emitted for the type and schedules of reinforcement employed was relatively low. The author therefore returned to a lever-press response mechanism and, after experimentation with more than 50 children, decided that this type of manipulandum is entirely adequate. Each response on the lever is recorded on a cumulative recorder and a counter. Also, each reinforcement delivery is registered on the cumulative marker and a second counter. Reinforcers attempted to the date of the article included cookies, animal crackers, M and M candies, small pieces of colored paper, cereal and tokens. Two research projects were undertaken using the above procedures. The first one was to determine whether it would be feasible to conduct further research on an individual analysis design, i.e. a procedure in which each child serves as his own control. The second project was concerned with changes in some of the basic processes (strengthening, extinction, discrimination, and differentiation), as related to three maturation levels of preschool children.

Results of only the first study are given since the second was in progress at the time this article was written. Sample data were given for two four year old boys who both showed reasonably constant patterns of responding. Reinforcements in these sessions consisted of a standard mixture of trinkets, cookies, Trix, and M and M candy. The experiments were aimed toward increasing the sensitivity of the response measure and

increasing control over independent variables.

Bijou (6) continued his research with experiments on extinction. He investigated the problem of whether variable ratio intermittent reinforcement training results in more resistance to extinction than continous reinforcement training when the number of reinforcements is held constant. Two experiments involving operant conditioning techniques were performed with 39 preschool children. Six reinforcements (plastic trinkets) were used in the first experiment, five in the second. Results agree with studies using subhuman subjects in that the intermittent reinforcement showed more resistance to extinction than the continuous reinforcement. However, they were significant between the 5 and 10 per cent levels of confidence. A lower level of confidence might be desirable for purposes of prediction. Bijou (7) also presented some findings on operant experimental extinction in young children after conditioning on three fixed intervals of reinforcement. The results reported are based on investigations during 1956 and 1957. Behavior during extinction was observed in four preschool children following training on fixed interval schedules of reinforcement of 20, 30, and 60 seconds. The results showed that, (1) the rate of the cumulative extinction curves appears to be related in rank order fashion to size of fixed interval over the range observed, and (2) there is no clear-cut relationship between base-line performance and extinction. It is the author's impression that, compared with infrahumans, children

show tremendous variability in number of responses during extinction for a given schedule of reinforcement. In addition, children alter experimental extinction by introducing stimuli not under the control of the experimenter.

The authors presented a clear, informative article. Two points, however, deserve mention. Each child tested was permitted to remain in the experimental room as long as he wished. One child remained 15 minutes; a second, 20.8 minutes; and a third, 36 minutes. The comparisons between the children regarding number of responses and number of responses per minute may not be valid if these measures were influenced by the time spent in the experimental room. Secondly, it would have been interesting to receive information on the qualitative changes which occured among the children when comparing regular sessions to extinction sessions.

During 1958 and 1959 experimenters continued searching for more durable reinforcers and began using different schedules. Long, Hammack, May and Campbell (17) used children varying in age from four to eight. They were reinforced intermittantly with trinkets, pennies, and projected pictures. Attempts were made to use children three years or younger but were unsuccessful because the children refused to remain alone in the experimental rooms. The instructions to each child were both demonstrational and verbal. Trinkets, pennies and projected 35 millimeter

Kodachrome transparencies were used as reinforcers. The pictures were not used alone but in conjunction with other reinforcers. They were changed at the time of reinforcement and then would remain projected while the child worked for the next trinket or penny.

One of the most important conclusions derived from this article concerns beginning schedules for children. There seems to be little difficulty in initiating a particular schedule of intermittant reinforcement with lower animals. With fixed ratios (one reinforcement to a fixed number of responses) this ordinarily has been accomplished by starting an animal on continuous reinforcement and then shifting him to small fixed ratios which are later increased in size. Changes such as these were found by the authors to be more difficult to effect in children. Continous reinforcement or prolonged reinforcement on small FR's frequently produced rapid deceleration of the over-all rate within that particular session. On the other hand, beginning a child on a ratio which was too large frequently had equally unfortunate effects. The best technique appeared to be to start the subject on FR 15 and then increase the size of his ratio within that session. Surprisingly strong FR control was developed in this way.

The authors reported other related conclusions: (1) Responding which was reinforced intermittantly with trinkets on

FR schedules closely resembled that reported for other organisms reinforced with homeostatic rewards. (2) First session FR schedules of 20 or less frequently produced a deceleration of overall rate which was characterized principally by increases in length of pausing after reinforcement. This was viewed as being similar to the satiation effects reported by Ferster and Skinner for other organisms. (3) Fixed ratios could be increased to 50 or 60 if sufficient control was developed with smaller ratios and if the reinforcing effect of the trinkets had not been reduced. (4) Fixed ratio schedules, in general, were found to exercise considerable control over performance. Almost all children showed great sensitivity to them.

The authors concluded that analysis of data indicate that in most instances the performance of children was similar to that reported for other organisms. The implication of this is that almost as much experimental control can be gained over the behavior of children as that of lower organisms. The authors felt that their own reinforcers had many limitations and that if more powerful reinforcers could be discovered and used, the lack of extra-experimental control, short sessions, etc., might come to have little or no negative effect.

As in previous articles nothing is reported regarding the type of pictures used as reinforcers. Little information is given about the length of time the pictures were shown or why

they were used in conjunction with other reinforcers. If two reinforcers are used similtaneously few conclusions can be drawn about either one.

Bijou and Sturges (5) began more specific experimentation on reinforcers. They were the first to divide reinforcers into catagories and analyze the kinds and the ways that positive reinforcers may be used in experimental studies with children. Two of these, consumables and manipulatables, are presented in this paper. Visual and auditory stimuli, social stimuli, and tokens are to be presented in a future paper. By positive reinforcers, the authors refer to those classes of stimuli which upon presentation strengthen the behavior that they follow. A large variety of edibles has been used with children in both multiple-choice and free operant tasks. Five experiments are cited all of which allowed the child to do as he pleased with the reinforcers. Findings were brought together in the form of practical suggestions for the use of consumables as reinforcers. Among the suggestions given were: (1) Parents, teachers, etc. should be informed on the kind and amount of consumables each child will receive in order to insure cooperation. (2) Select the type of consumable that is acceptable to parents, teachers, etc. The consumable should have low calories, have a hard surface so it will not readily stick, melt, or crumble. (3) Minimum instructions should be given and reinforcers should be delivered by mechanical or electronic means. To encourage

investigations aimed at duplicating, elaborating and extending findings, the authors suggest that a complete and detailed account be given of the consumables used, the instructions employed, the method of dispensation, and the controls exercised over other social and physical stimuli.

Manipulatables refer to toys, trinkets and hobby items. Several studies were cited using these reinforcers and suggestions were made as follows: (1) As with consumables, parents should be aware of the nature of the experiments and reinforcers given in case of objections; (2) In selecting manipulatables the experimenter should, a) make sure they are appropriate for the particular group of subjects under study (age, sex, socio-economic status, etc.), and b) materials that may cause hurt or disturbance such as buttons which can be put in the mouth, noise makers, wind-up toys, etc. should be avoided; (3) make clear the conditions under which the manipulatables were displayed and given.

The research presented here is of the kind much needed in the field of operant conditioning. Seeking results too soon may defeat the purpose of this technique. The study of reinforcers must come before practical results can be expected. This study would have been even more informative if more attention would have been given to the conditions influencing the reinforcers used. These might include the age of the child and such situational factors as the instructions about the nature of the experimental task and about disposition of the reinforcers.

In 1959, Long (18) published an article bringing together some of the research previously reviewed. In addition, the article dealt with theoretical and practical applications of the operant method of studying child behavior and covered experimental work done over a period of three years. The apparatus described in this research is the most variable of any presented so far. It consists of a manipulandum (an enclosed telegraph key), colored lights, used as discriminative stimuli, a translucent screen on which pictures or other stimuli are projected, and a tray into which reinforcers are delivered. Trinkets, pennies, and projected 35 mm. Kodachrome transparencies were used as reinforcers. Several records were shown. By studying changes in rate patterns the author has shown that it is possible to demonstrate with children the effects of various schedule and motivational variables on performance. He suggests that the data while less lawful do resemble rather closely those produced in other organisms.

In a later discussion of Long's article, Gewirtz makes mention of the reinforcers used with humans and animals. He states that, unlike Long's subjects who became satiated rather quickly, animal subjects responding for the conventional reinforcers of food or water almost never satiate. This is because the experimenter fairly well understands how to apply the deprivation-satiation laws for food and water to his subject, and hence can keep that subject on an effective deprivation

schedule while he dispenses the reinforcer in relatively small amounts. Gerwirtz suggests that such reinforcers as trinkets, etc. also might be responsive to deprivation and satiation operations of a similar order as those controlling the reinforcers of those drive systems commonly labeled primary appetite.

Long used several reinforcers in his work with children. However, no discussion is made of the comparative value of each reinforcer. Also no mention was made regarding the kind of pictures used or how they were chosen or presented. More information would be needed to duplicate fully the research presented here.

In a discussion of this article Gerwirtz stated that reinforcers such as trinkets might be made responsive to deprivation and satiation operations of a similar order as that of food and water for animals. It appears doubtful that this suggestion could be followed through and Gerwirtz offers no practical means by which it might be done.

Bijou (4) summarizes attempts to apply behavior theory to learning in children. He begins with Watson and ends with Mussen and Conger. He shows that the principles usually employed have been extrapolations by analogies from animal studies and that concepts were not used as originally intended. Bijou suggests that research in child development move toward an empirical behavior theory. This approach implies the following:

(1) the developing child is conceived of as a source of stimulus and response functions; (2) the circumstances of development are treated as a series of environmental units each conceptualized in stimulus functions and other operations; and (3) the interactions between the two sets of terms are formulated as functional relationships. The author further suggests that such a program would gain momentum if it were to start with studies aimed at evaluating on children empirical laws from animal observations and were to be followed with investigations designed to amplify and extend the principles.

The author appears to be concerned with the fact that progress in child psychology has been slow compared to other fields of psychology. As a solution he suggests an empirical behavior theory for child development based on operant conditioning techniques. The only point he makes which may be open to criticism is his apparent belief in the projection of animal studies to the explanation of child behavior. There is some danger in saying that because two cumulative records look alike that the same forces were in operation which produced both. Bijou resolves this criticism in the following research.

Bijou, in an article as yet unpublished (8), reports some of the first experimental work done at the Institute of Child Development at the University of Washington. The author states that it is well established that unequivocal relationships

between manipulated variables and operant behavior can be demonstrated in single infrahuman organisms. The question he raises is whether such can be shown in research with young children. Data from three preschool children showed that stable performance of two minutes of responding in the presence of an amber light and two minutes of no responding in the presence of a blue light (a pattern which took from six to eight days to establish) was altered by the introduction of a pair of toggle switches allowing the child to control the lights. The discriminative performance of one child was most affected the first day after installation of the switches, less on the second day and by the third day it was similar to the baseline performance. The behavior of the second child showed the opposite trend. Alteration in discriminative behavior after experimental modification was slight on the first day and increased on the second and third days. Recovery began on the fourth day. The third child, like the first, showed the greatest change on the first experimental day. However, her "recovery rate" was slower than the first child's for in the fourth session after installation of the switches, her performance was still far below the efficiency shown on her baseline day. These data are taken by the author as support for the contention that individual experimental analysis is feasible with young children since a clear functional relationship has been shown between a stable baseline performance and the introduction of a special stimulus

condition.

The results of this article are conclusive and well presented. However, the research introduced one variable which was not discussed. The author states that "the experimenter brought the child into the room and remained with him during the session . . .". Did the children require this procedure, and what effect did the presence of an adult in the experimental room have on the results?

The work with normal children has motivated several researchers to investigate the possibility of using operant techniques with the mentally retarded. Ellis, Barnett and Pryer (9) report on exploratory studies done with mental defectives. They attempted to relate indices of cumulative records to organismic variables such as I.Q., M.A., C.A., clinical types and schedules of reinforcement including fixed and variable interval and fixed ratio. The experimental rooms as described constitute a great improvement over others so far described in the literature. The interior was painted flat grey; frequently distracting stimuli such as door knobs, light switches, and other fixtures were removed. The room was sound-treated and air conditioned. A two-way sound system permitted communication between E and S. One-way mirrors were mounted between these rooms.

The first study used twelve males with I.Q.'s of 30 or less and C.A.'s from 15 to 38. M and M candies were used as reinforcers. During the initial session each subject was

exposed to a continuous reinforcement schedule and after some control was established, switched to fixed ratio 10 (FR 10). The FR records tended to be stable, smooth and linear. In a second study the authors were interested in a further analysis of ratio behavior. Twenty teenage and adult males with M.A.'s ranging from 3 to 9 years were selected. I.Q.'s were from 30 to 70. Both higher M.A. and C.A. subjects performed at higher overall rates. Also the character of behavior differed as a function of I.Q. The lower levels showed more erratic behavior with pauses between high rate bursts. All subjects were maintained on FR ratios until they failed to increase for two consecutive days. These studies suggest that defectives with extremely limited skills adapt readily to the operant conditioning procedure. Many of these were of the type usually labeled "untestable" and are not usually included in experimental studies. The majority of subjects, even those of lowest intelligence, were sensitive to schedule changes. Interval and ratio schedules produced fairly distinctive records. The record of the severely defective subject is particularly like that of the psychotic, i.e., containing frequent pauses. Overall rate of response was shown to be related to C.A. and M.A. Subjects were sustained for long periods on very high ratios for candy or cigarette rewards. The authors believe the analysis of operant behavior holds promise for the training of severely defective humans.

The authors have presented a good exploratory study showing clearly the feasibility of using operant conditioning techniques with the mentally defective. Unlike several previous studies the authors discussed the method of delivering reinforcers and gave examples of how typical subjects handled them. They state, however, that results should be interpreted with caution since the work was largely exploratory.

At the Psychological Research Laboratory at the Rainier School, Buckley, Washington, Orlando (21) is directing a considerable amount of research in operant conditioning. This unpublished research covers a period from June, 1958, to January, 1960. The program aims to study, by means of laboratory-experimental procedure, the development and maintenance of motor and verbal discriminative behavior and the conditions under which efficient and complex discriminative behaviors may be evolved in retarded children. It also aims to compare findings to normal children. The work for the two year period is described in three phases. Phases I and II concerned a search for personnel, establishment of a research laboratory, working out operational procedures, and exploring basic methods appropriate for retarded children. Phase III involved the launching of formal studies and the investigations of new problems and techniques. The first study initiated concerned discrimination and will be described later. The second study was concerned with verbal (vocabulary)

operant conditioning. The task of building a verbal repertoire involved a Hunter Cardmaster for presenting words, an intercommunication system for prompting and a bank of lights and dispenser for reinforcements. The study was predicted on the assumption that if a child could say a word in the presence of that word on a card, such behavior could be strengthened. The main problems were concerned with reinforcers, scheduling of reinforcements, and the selection and arrangement of materials. The findings on three girls were encouraging, but it was decided that this area could be better approached from an automated teaching point of view using commercially prepared teaching devices. However, data have been collected showing that for practically all children, component skills required for learning a discrimination can be developed in a single session. Formerly it required 15 or more sessions. In addition to these studies attempts are being made, (1) to obtain measures of behavior under control of stimuli associated with non-reinforcement to get at something that the authors call "conditioned frustration"; (2) to analyze further the facilitory and inhibitory functions of relevant cues in discrimination; (3) to correlate changes in activity level and operant behavior with changes in stimulus conditions; and (4) to explore some aspects of social behavior as reinforcers as well as conditions for non-reinforcement. Some attention is also being given to two practical problems--the application of operant methods to evaluate hearing acuity and

to assess the influence of drugs. Specifically, the staff studies are concerned with such basic problems as the following: (1) Studies on techniques involving behavior under basic schedules of reinforcement, and rapid establishment of discriminations; (2) Analysis of the discriminative process by repeated reversing of positive and negative cues in a two response situation; (3) Exploratory studies on conditioned non-reinforcement, percentage reinforcement, and relative reinforcing values of social reinforcers. Staff studies are also concerned with applied problems such as: (1) Procedures for the strengthing of vocabulary responses and (2) Development of a non-verbal technique to assess hearing acuity. Graduate students are working on the following projects: (1) The role of mild-aversive auditory stimulation on speed of discrimination learning; (2) The roles of verbal vs. non-verbal pre-training in discrimination learning; (3) Operant measures of the effect of psychosedative drugs; and (4) The influence of loss of reinforcements to a peer on base-line performance.

Orlando's personal communication, while not revealing fully all techniques and results, makes one point clearly evident. Experimenters are beginning to seek out practical applications for the techniques of operant conditioning. This area of research is gradually moving out of the exploratory stage to the level of practical need. The following work in progress substantiates this observation.

Much unpublished research is currently being conducted in different parts of the country. In personal communications the following were kind enough to report on their work:

(1) Levin sent a summary of his cur ent research. All of his operant conditioning research has employed a marble-dropping task similar to that of Gewirtz and Baer. His main interest has been in such verbal social reinforcers as "good". One series of studies was conducted in collaboration with Ruth Nishimura and John Simmons at the N. J. Neuro-Psychiatric Institute (NJNPI). Another series was started in elementary schools in Rhode Island.

Levin's research at NJNPI employed S's who were severely disturbed emotionally. All of them were in residential treatment. The most interesting finding to date was that saying "good" did not appear to function as a reinforcer for most of these children. Presumably, Levin's instructions, "please play a game", and/or some other reinforcer were the motivating variables. Another suggestive finding was that for four hyperactive, destructive boys between six and fourteen in age saying "good" seemed to have aversive properties. A sliding ratio schedule was used (reinforced with peanuts) so that the boys started at FR 1, continuous reinforcement, and were soon brought up to FR 20.

Levin has also recently gathered some data on normal children in kindergarten. Preliminary analysis suggests that saying "good"

produced more responses from girls than no verbalization (N = 24, probability about .10 with a two-tailed test). However, "good" appeared to have no effect on the boys (N = 19). Levin's present plans are to vary systematically the instructions, social reinforcers, and such variables as prior relationship between E and S until a clearer picture is presented regarding Ss responses.

(2) Osler reports that she is working on several publications in the field of operant conditioning with regard to concept formation. It is she who developed the film strip projector used in the present research.

(3) Michael and Meyerson report that they have been using operant conditioning with mentally retarded children but have not yet published any findings. The major aim of their work has been to measure sensory thresholds and good progress is reported. They also report that they have accumulated numerous other observations of behavior all of which, however, are quite tentative.

The Harvard Medical School which is acting as a voluntary central processing center reports other research in different schools and hospitals. Azrin is working with normal adults, and psychotic children and adults. Bijou is continuing his research with normal children 2-12 years old. Bullock is working with psychotic adults and investigating the effects of drugs on schedules of reinforcement. Deives is also investigating

schedules and drugs, but with medical students and prisoners. Ellis is continuing his work with retarded children. Etsten is investigating the effects of anesthesia on surgical patients. Wyckoff is using college students as a means toward investigating social behavior. Finally, Zeamon is investigating discrimination with retarded and emotionally disturbed children.

The following is a summary of the literature presented in this chapter. Skinner first developed operant conditioning techniques with lower organisms in 1938. It was sixteen years later, in 1954, that he began his experiments with psychotics. These were largely exploratory studies although changes in the behavior of several patients was observed. The results prompted the author to feel that the operant method could be adaptable to other clinical types as well as psychotics. The long range aim of the experimentation was to gain control of the patient and to devise methods of expanding this control outside the experimental room. The largest question raised by his research concerned the possible transfer effects to other tasks and situations. Another question raised concerns the justification of acquiring "control" over human beings. Many psychologists feel that the means are justified if results continue to be promising.

Skinner, Solomon and Lindsley (14) continued expanding research facilities and acquiring data on psychotics. The equipment improved rapidly and so did the techniques. A

relationship was now becoming evident between rate of response and "severity of illness". However, one of the criticisms of this research mentioned previously is that no measure of "severity of illness" was given. Rate of response, however, was found not to correlate with ratings of patients' verbal behavior, admission I.Q.'s or total years of hospitalization.

Linsley (15) continued research with psychotics and reported clinical improvement in several patients. However, he does not give evidence to support this statement. The author lists advantages and disadvantages of the method.

The third year of this research, reported by Skinner, Solomon and Lindsley (16) included over 10,000 patient hours on 51 adults. This research explored different reinforcers and is more directly related to the present research. Pictures (male nudes) and candy appeared to work best with the sample used.

Mednick and Lindsley (19) were the first to compare rate of response with several psychological tests and rating scales. Statistical analysis was used regarding the relationship between rate of response and these clinical tests. Little information was given concerning the individual tests. The research, therefore, does not add substantially to that already reported.

Ferster (11) has completed one of the few studies with psychotic children. It is also among the first research aimed at a practical rather than theoretical goal. Reinforcers used

included slides projected on a screen. One of the criticisms aimed at Ferster's report concerns his lack of discussion of what these pictures were and how they were chosen.

Since Skinner showed that operant techniques could be used with human beings, several authors developed an interest in using the method with children. Bijou was the pioneer in this work and published some of the first research in the area. He first described (3) a laboratory method for the systemtic study of the behavior of preschool children. He developed the apparatus used by several later experimenters which consisted of a device delivering a trinket when the subject dropped a ball into a hole. The limitations of this type of apparatus were discussed. Mention was made by the authors of the large satiation effects observed. They stated that more durable reinforcers were needed.

Azrin has also been among the first researchers working with children. He reported using operant techniques to establish, control, and eliminate cooperation among children (1). The cooperation reported is of limited value but suggests the possible far-reaching effects of this type of research.

Bijou later refined his techniques for working with children and reported these revisions in an article dealing largely with reinforcers (2). He reported on attempts to use cookies, animal crackers, M and M candy, colored paper, cereal, tokens and plastic trinkets. Efforts still were being aimed at

finding more durable and versatile reinforcers.

From among the reinforcers mentioned above Bijou (6) decided to use trinkets as reinforcers in an experiment designed to study extinction in children. He investigated a problem which has been explored conclusively with lower organisms. That is, will variable ratio intermittant reinforcement training result in more resistance to extinction than continuous reinforcement training. Variable ratio training was shown to be more resistant to extinction.

In another article dealing with extinction, Bijou (7) presents findings which show that the rate of the cumulative extinction curves are related in rank order fashion to the size of the fixed interval. This means that the larger the fixed ratio of training the child has the more he is resistant to extinction.

The search continued for more durable reinforcers. During 1958 Long, Hammack, May and Campbell (17) reported on a sample of children from age four to eight. Reinforcers used included trinkets, pennies, and projected pictures. As in a previous article (11) no mention was made of the type of pictures, method of presentation and method of choosing the pictures. Important mention is made of the best beginning fixed ratio. In previous articles children were begun on continuous ratio and worked up to higher fixed ratios. This article reported that a fixed ratio of 15 (FR 15) works best. However, the authors gave no

experimental evidence in support of this report.

Bijou and Sturges (5) decided to catagorize reinforcers more specifically and reported on an experiment dealing with consumables and manipulatables. No discussion was given to which kind proved more durable. Instead, the authors bring their findings together in the form of practical suggestions for other experimenters using either kind.

Long (18) using trinkets, pennies, and 35 mm. transparencies as reinforcers reported on work dealing with both theoretical and practical applications of the operant method. As in two previous articles (11, 17) no mention was made of the kind of picture reinforcement used. Long reported that his reinforcers did seem to have limitations in durability and versatility.

In 1959 Bijou (4) summarized attempts to apply behavior theory to learning in children quoting studies from Watson to Mussen and Conger. He suggested that research in child development move toward a more empirical behavior theory. He also suggested expanding animal studies to include children. In an article as yet unpublished (8) Bijou reported on research designed to show that unequivocal relationships between manipulated variables and operant behavior can be demonstrated in research with young children as well as with infrahuman organisms.

Several authors have been motivated to expand the type of subjects used in operant conditioning research and have completed and are working on experiments with the mentally deficient.

Ellis, Barnett and Pryer (9) were among the first to explore this area. They report on exploratory studies relating indices of cumulative records to organismic variables such as I.Q., M.A., C.A., clinical types, and different schedules of reinforcement. The authors report improved equipment and experimental rooms. M and M candy was used as a reinforcer. Subjects included twelve males with I.Q.'s of 30 or less and C.A.'s ranging from 15 to 38. Results appeared to indicate that the analysis of operant behavior holds promise for the training of severely defective humans. The results were stated by the authors to be largely exploratory.

A report was given regarding Orlando's unpublished research with retarded children (21). His research is aimed at practical results and studies now being conducted include work on the maintenance of motor and verbal discriminative behavior and the conditions under which efficient and complex discriminative behaviors may be involved in retarded children.

A report on other unpublished research being conducted throughout the country was given. Mention was made of the Harvard Medical School which is acting as a voluntary central processing center for other research being done in different schools and hospitals.

The research on the experimental analysis of behavior has evolved from exploratory studies to research of a practical and far-reaching nature. Throughout the literature, however, the

problem of reinforcers is recurrent. More durable and versatile reinforcers are still needed especially in work dealing with children.

Chapter III

Design of the Equipment

Laboratory apparatus for the experimental analysis of behavior emphasizes flexibility and adaptability. The essential parts of any operant conditioning apparatus are: (1) a suitable enclosure, excluding undesired variables; (2) a manipulandum for the desired response being studied; (3) a reinforcement magazine to present standard quantities of the reward used to maintain the response; (4) a stimulus panel for presenting the stimuli used for discrimination purposes; (5) recording equipment for the automatic recording of the responses; and (6) controlling equipment for the automatic scheduling of the various stimuli whose effects are being studied. The automation of the recording equipment excludes the human error in experimental observations while increasing data productivity.

When the method of operant conditioning is applied to a new organism, the biggest problems are always those of apparatus design and construction. The apparatus and procedural modification developed for use with children are described below:

(1) Experimental enclosure: ideally the experimental rooms should be sound-proofed, indestructible, pleasant, and easily cleaned, and should provide for one-way observation, and a means

of presenting reinforcing and discriminative stimuli. The experimental room used in the present study is illustrated in Figure 1.

Although lack of space was a considerable problem, the room was kept as free as possible of other equipment and supplies. At one end of the room was placed the reinforcement panel and a chair (see Photograph A). The panel included the bar which the child pressed, a cup to catch marbles, trinkets, etc., and mounted on the face of the panel before the subject a 4 x 6 inch translucent screen on which reinforcing pictures could be projected. Although recording equipment was contained in another room, the child could be clearly seen by the experimenter through the use of a double mirror arrangement.

This arrangement had its limitations. The child could be seen clearly only when he was sitting or standing near the manipulandum. When a child wandered to other parts of the room observation was difficult. Also, the lighting in the room occupied by the experimenter needed to be regulated. If this room was too light it was possible for the subject to see the experimenter by looking into the mirror outside the experimental room. A one-way mirror installed in the wall of the experimental room would have been the best solution. Installation of this mirror would have been expensive, however, and also would have disrupted other work in progress in the laboratory.

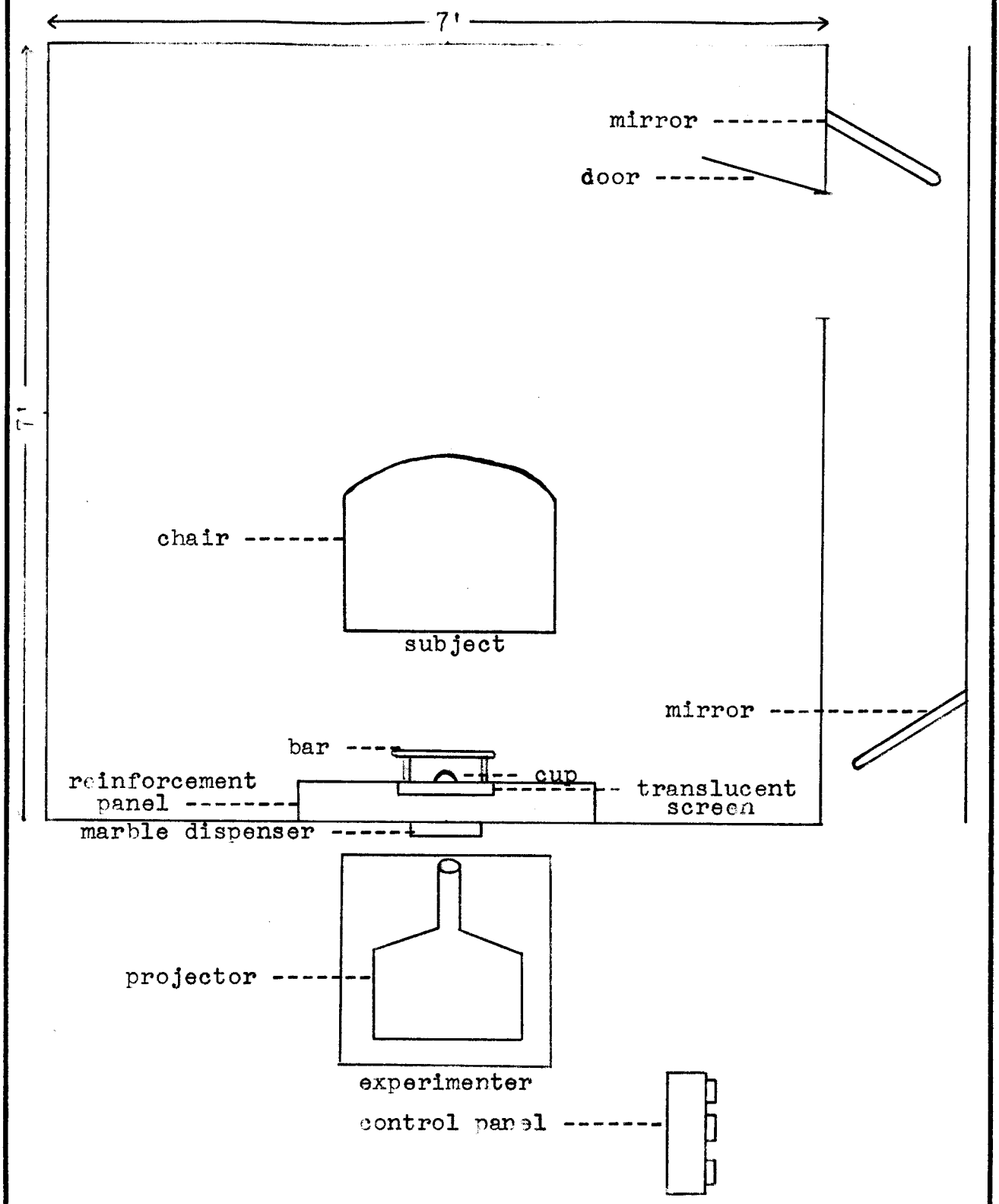


Fig. 1. Layout of experimental room.

Photograph A

Reinforcement Panel

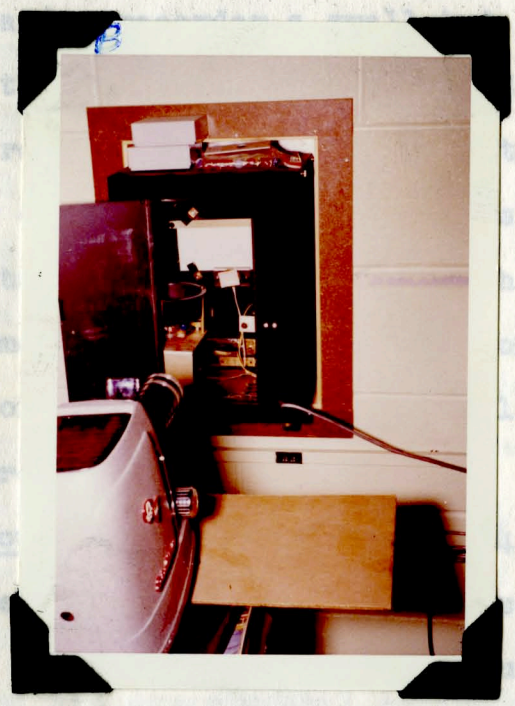
(2) Manipulandum: This consisted of a wooden bar with smooth edges placed approximately three feet from the floor within easy reach of a child whether standing or sitting. The bar is shown clearly in Photograph A.

(3) Reinforcement magazines and stimulus panel: Two methods of reinforcement were possible with the present apparatus. Any round objects the size of marbles (gum-drops, trinkets contained in plastic balls, etc.) could be delivered into the cup placed just below the bar. Also, it was possible to show black and white or color film strips on the translucent screen by

means of an automatic projector located in the recording equipment room. The projector used was a 35 mm. Graflex Schoolmaster. The projector, marble dispenser, and screen are seen in Photograph B from the experimenter's vantage point.

Photograph B

Reinforcement Equipment



(4) Recording equipment: A Gerbrands cumulative response recorder and reset counter were used to record the responses. Each experimental session was characteristically reported in a cumulative response record (to be described later), in counter readings, and in qualitative observation reports. The apparatus provided complete automatic control of any preselected schedule

of reinforcement and the entire session was programmed and recorded automatically.

Briefly, the following occured each time a subject pressed the bar which was connected to a recording apparatus in an adjoining room. The response was indicated by a moving pen on a continuous sheet of paper. This produced a series of records like those shown on page 59. Every response advanced the pen upward on the cumulative recorder a small but constant amount. The paper on which the responses were recorded was pulled to the left at a constant rate. Thus, changes in rate of responding could be studied by examining the changes in slope of the cumulative records: a steep slope indicated a high rate of responding; a less steep slope meant a lower rate of responding; a horizontal line showed no responding (pausing). The small diagonal strokes indicated the occurrence of reinforcements.

(5) Miscellaneous equipment: An Argus C-4, 35 mm. camera was used to take the pictures used as reinforcers. The film used was Kodachrome reversal color film. Illustrated below is a sample of four pictures from one of the film strips used.

Film Strip

Stimulus Pictures

(6) Controlling Equipment:

a. Response Translation Panel: In a very real sense, the response translation panel represented the subject in the control apparatus. This unit translated behavior into regulated electrical pulses that reliably activated the control and recording devices. The unit was operated by the bar described above.

b. Relay Panel: This apparatus comprised two relays which made the equipment more versatile.

c. General Purpose Timer: The timer proved to be a very versatile piece of equipment that played an important part in the present research. With its associated circuitry, the timer could be used to program spaced responding, fixed-interval reinforcement schedules, or any contingency that involved a time interval following a response or environmental event.

Generally speaking, the automatic equipment described above was developed in order to establish and maintain contact between the subject and the experimental environment. The subject's behavior made contact with the environment via the response translation panel. The environment, in turn, was fed back to the subject via the reinforcement panel. In most experiments, however, the environmental consequences of the subject's behavior conformed to certain rules. For example, a response may produce a reinforcement only when a certain stimulus is present; behavior may be punished only after a certain period

of time has elapsed; a reinforcement may be given only after a certain number of responses has been made.

The application of this equipment was governed by a single general principle: each rule imposed upon the behavior-environment relationship is embodied in an electrically operated switch, placed between the response panel and the reinforcement panel. When the switch was open, the response could not get through to the reinforcement panel. When the switch was closed (i.e. the bar pressed) contact was established between behavior and environment. By employing the units singly or in combination it would be possible not only to program established experimental procedures but also to create new procedures of almost unlimited scope.

Chapter IV

Design of the Research

As in experimental work with animals, it is highly desirable to have a standard preparation for child subjects. This preparation serves to reduce the influence of emotional reaction to a new situation on the behavior to be observed, and to minimize marked differences in rapport that may be established between the child and the experimenter.

Previous to any experimental sessions, each child was given a Revised Stanford-Binet intelligence test, 1937 edition. This served two purposes. First, information was acquired regarding I.Q., mental age, and facility of intellectual functioning. Secondly, it served as a good method for establishing rapport between child and experimenter.

The "Skinner box" used for the children tested was a room approximately 7 feet square. The reinforcement panel was arranged so that the child was required to make only a relatively uncomplicated response, the frequency of which could be automatically and objectively recorded.

Eight subjects were used in the study. Four children, two boys and two girls, had intelligence quotients 96 or above The second group of four children, also two boys and two girls, had I.Q.'s below 62. The average chronological age was 4-1

for the normal group and 7-4 for the retarded sample. Mental age averaged 4-5 for the children of normal intelligence and 4-1 for the retarded group. The normal group had an average I.Q. of 109, the retarded children an average I.Q. of 58.

On the first day of the study each child was brought into the laboratory by the experimenter. The child was told and shown how to press the bar for the reinforcement. He was then told "you may get more marbles--or look at more pictures". The child was then left in the room and observed through the double mirror arrangement. When the ten minute session was over, the apparatus was turned off and the child was led from the experimental room.

It had been found that an initial schedule of continuous reinforcement did not stimulate high FR records in later sessions. Thus, each child was begun on a schedule of FR 10. Once this ratio was established, usually in two or three sessions, an attempt was made to increase the ratio while maintaining a good level of response.

When marbles were used as reinforcement the child had to press the bar the required fixed number of times after which a marble was delivered to him. He could do whatever he wished with it. When pictures were used, the child had to press the bar the required fixed number of times after which a picture would be projected on the screen. The picture remained on the screen for four seconds after which the shutter would drop in

place and child would have to press again for the next picture. A four second interval was chosen because it was found that a mean time of approximately four seconds elapsed after a marble reinforcement was delivered before the child began pressing again. It was hoped, therefore, that the two reinforcements could be more rigidly compared. The sessions continued until the records indicated satiation effects (little responding) or until a durable interest was shown (continued high responding).

Lastly, each child was administered an extinction session for each reinforcer used. Each extinction session was performed in the following manner: Two reinforcements, marbles or pictures, were given on FR 10 and then no reinforcement was given for the remainder of the ten minute period. The number of responses in each extinction record were taken to be an indicator of the degree of interest each child had for the particular reinforcer used.

Two of the normal children were tested using marbles first then pictures as a reinforcer, and the remaining two were tested using pictures then marbles. The same procedure was followed for the retarded sample.

The pictures used were of two types. One strip presented colored animals and letters of the alphabet interspersed. The same strip was used for each child. A second film strip contained pictures of the individual subject's own parents, brothers and sisters, and favorite toys such as stuffed animals, balls

and tricycles.

The family pictures were taken by the experimenter in order to insure experimental control. That is, the pictures were taken in as consistent a manner as possible regarding sequence, activity and subject matter.

The first four pictures were of the subject with two or three different toys, the next two pictures were of the mother, followed by two of the subject and mother. Next, a picture was taken of the mother alone followed by a picture of the subject alone. Three pictures followed of the subject at play with other children in the family. Then three pictures were taken of the subject alone in various poses. The next two pictures were of the whole family followed by two pictures of the subject and father. It is felt that these picture sequences controlled in this manner provided a common factor for each child.

At the completion of the testing, reports were made on each child in the following way: A table was constructed showing the number of responses for each experimental session, the difference in percent of responses between the different reinforcers, and the different schedules used. The family pictures were combined with the animal pictures as compared to marbles since the study is designed to show the almost unlimited versatility of pictures as reinforcers. The table also shows the average number of responses made for the total number of sessions. A t-score was computed which indicated the significance with which the

reinforcers differed. A frequency polygon was constructed comparing the number of responses given for each reinforcer in each session.

Several other tables are given comparing the reinforcers on a group basis with regard to extinction trials and average number of responses per minute. Correlation coefficients were computed for the normal and retarded groups comparing rate of response with I.Q., and also comparing mental age with average number of responses for each reinforcer.

In addition to the above, each subject's performance was qualitatively analyzed. So that this analysis can be followed clearly, every record made by each child is presented.

Chapter V

Analysis of Results and Interpretation

Following the procedure outlined in Chapter IV, the test data have been analyzed to determine the relationship between the different reinforcers used in this experiment. First, each child's records are analyzed and interpreted.

Subject A was tested using marbles and then pictures as reinforcers. Her chronological age was 2-8, mental age 3-3, and I.Q. 123. Table 1 indicates the number of responses for each experimental session and the increase in percentage of responses of one reinforcer over the other. Subject A made a significantly higher number of responses for pictures than for marbles ($p < .001$). Figure 2 illustrates graphically the differences between individual sessions.

Records A1 through A5 show the erratic performance and rapid satiation which took place during the sessions using marbles as reinforcers. Under each record is shown the schedule, reinforcer used, and number of responses made. After two poor FR 20 performances (A4 and A5) the subject was returned to an FR 10 schedule in an attempt at reviving a good response rate. This was not successful.

Using pictures as a reinforcer stimulated a high rate of interest. Records A7 through A15 are seen to be more consistently

stable with fewer periods of pausing. The greatest number of responses took place during A10 during which pictures of the child, her parents, and favorite toys replaced the animal pictures used in the previous four sessions. It was possible to raise the fixed ratio from FR 10 to FR 60 in only eight sessions. The FR 60 record (A15) is comparable to those records made by lower organisms for reinforcers of food or water.

Responses per minute varied for marbles, from 6.5 to 32.2, and, for pictures, from 39.1 to 78. In five of nine sessions using pictures as a reinforcer, Subject A responded faster than once per second.

Subject B was tested using pictures and then marbles as reinforcers. His chronological age was 5-3, mental age 6-3, I.Q. 121. Table 2 indicates the number of responses for each experimental session and the increase in percentage of responses. His interest in marbles was much higher than that of the previous subject, but he still made an average of 33 per cent more responses for pictures than for marbles ($p < .01$).

Pictures of the subject, his family, and toys were given during B5 and he showed a significant and consistent increase as did Subject A. If record B5 (page 69) is observed, it will be noted at letter A that no reinforcement was given for approximately 60 responses. This was due to a mechanical failure. However, the continued high rate of response indicated a willingness (or degree of interest) to attain higher ratios in order to gain reinforcers.

Table 1

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject A

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	310	FR 10	478	35.2
2	FR 10	322	FR 10	391	17.7
3	FR 10	310	FR 10	407	23.9
4	FR 20	238	FR 20	398	40.0
5	FR 20	68	FR 20	780	91.1
6	FR 10	65	FR 20	621	
7			FR 40	663	
8			FR 60	723	
Average		218.8		557.6	
Percentage of the Difference in Average Number of Responses Between Marbles and Pictures					60.8

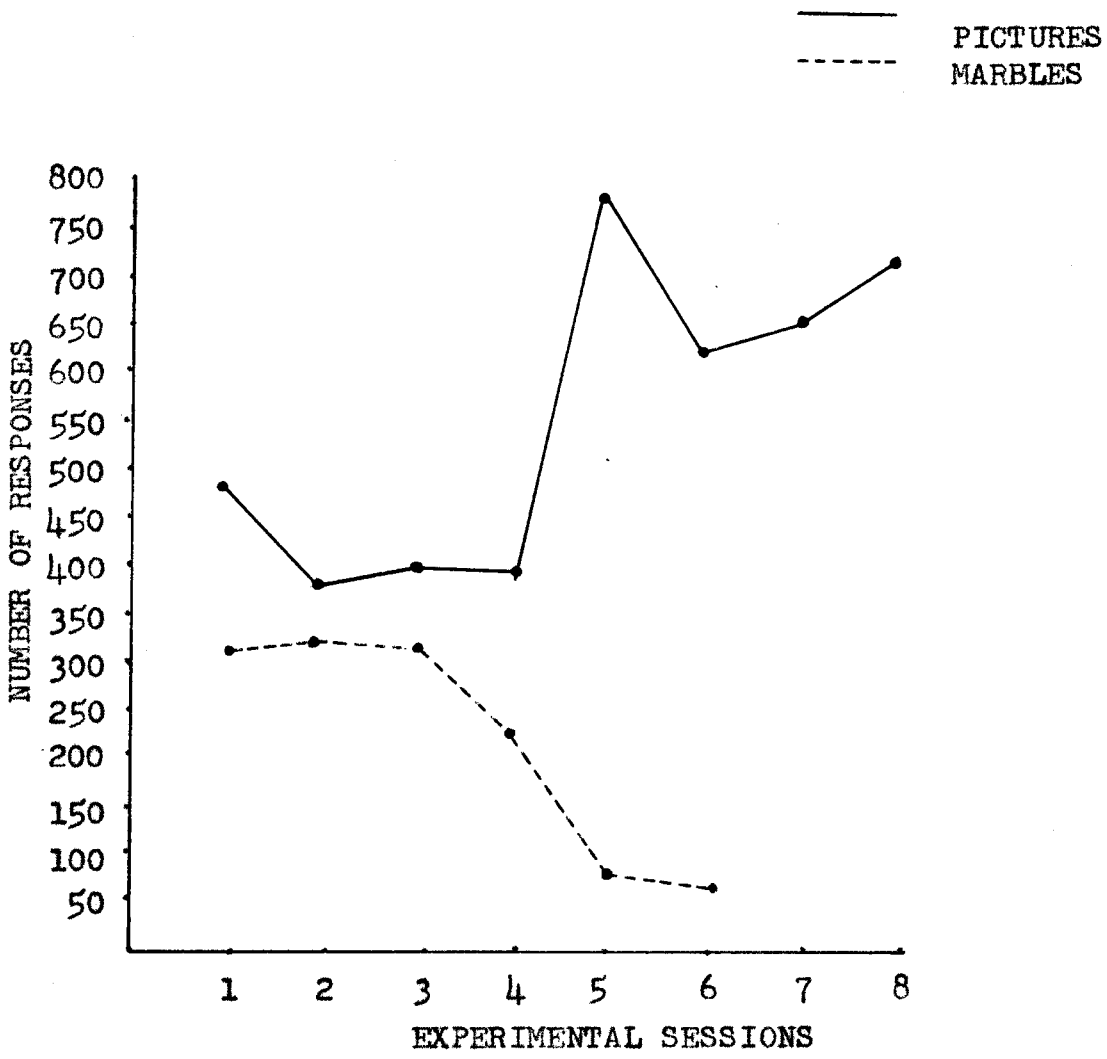


Fig. 2. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject A.

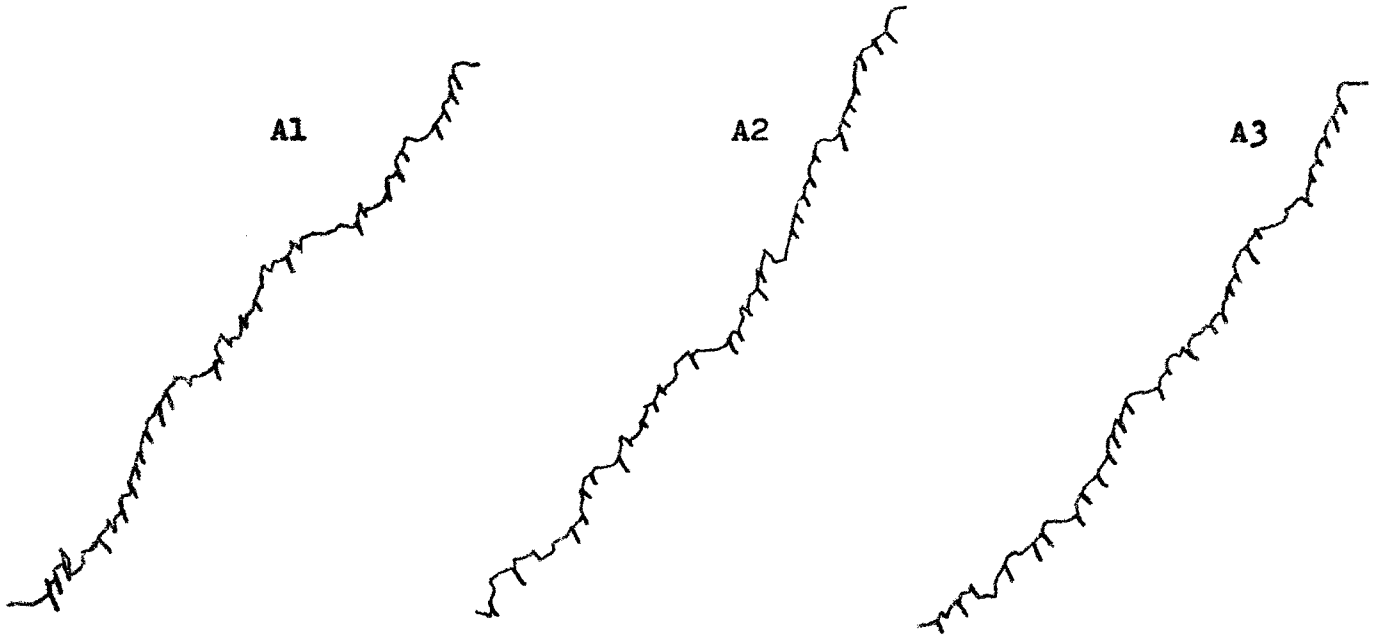
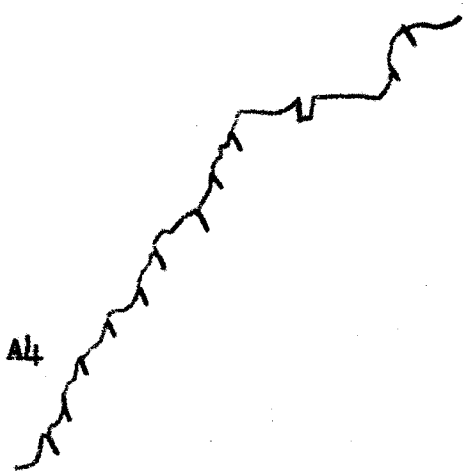
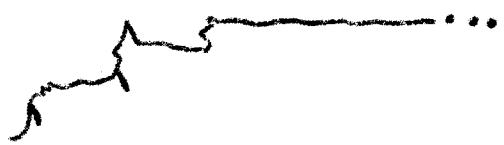


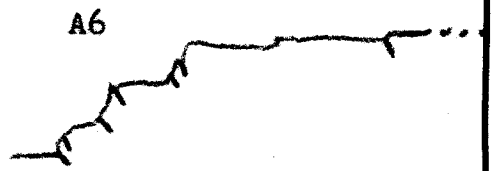
Fig. 3. Cumulative records, A1 through A3, for Subject A under the conditions noted.



FR 20, MARBLES
RESPONSES-238



FR 20, MARBLES
RESPONSES-68



FR 10, MARBLES
RESPONSES-65

Fig. 4. Cumulative records, A4 through A6, for Subject A under the conditions noted.

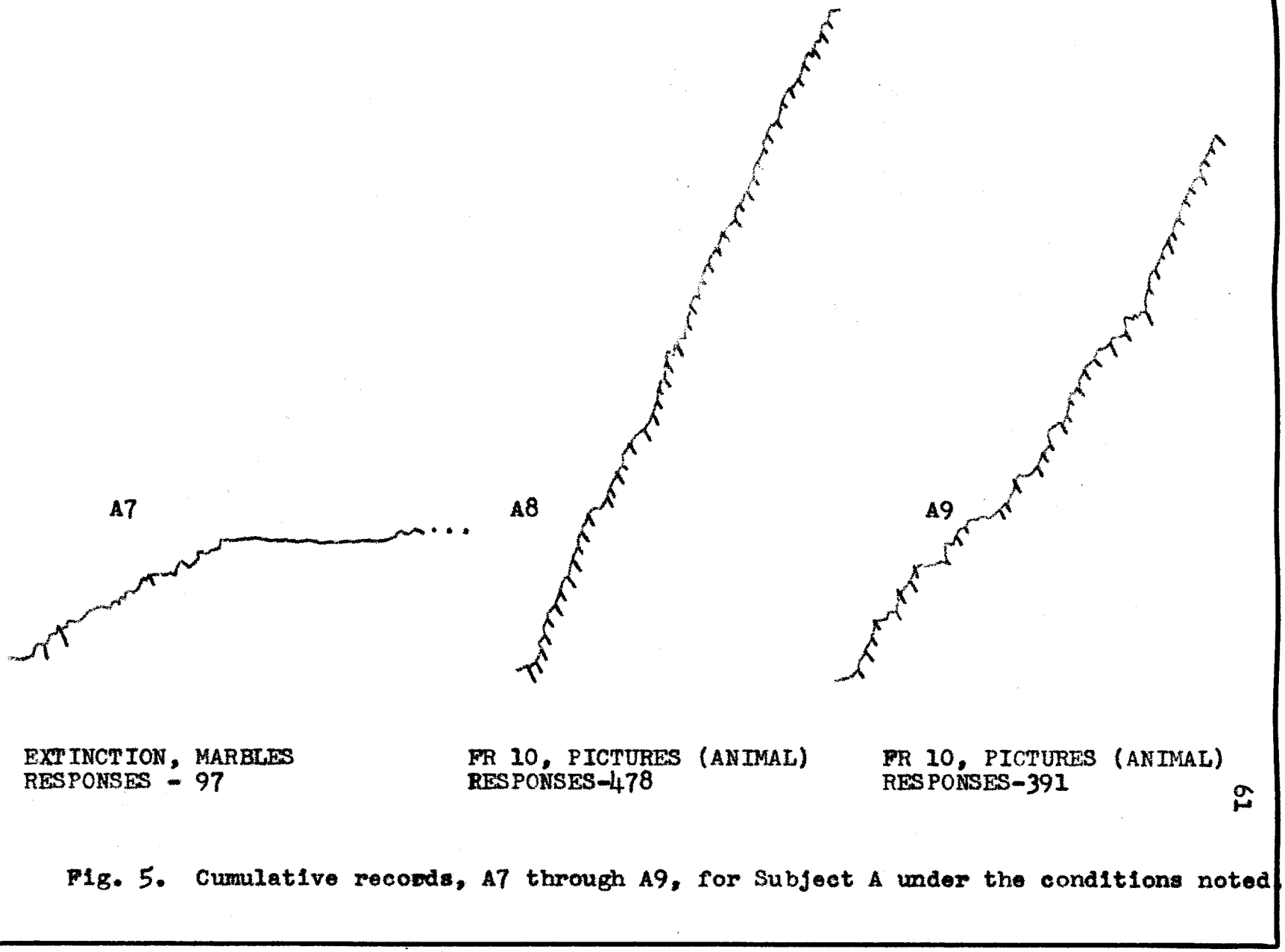


Fig. 5. Cumulative records, A7 through A9, for Subject A under the conditions noted.

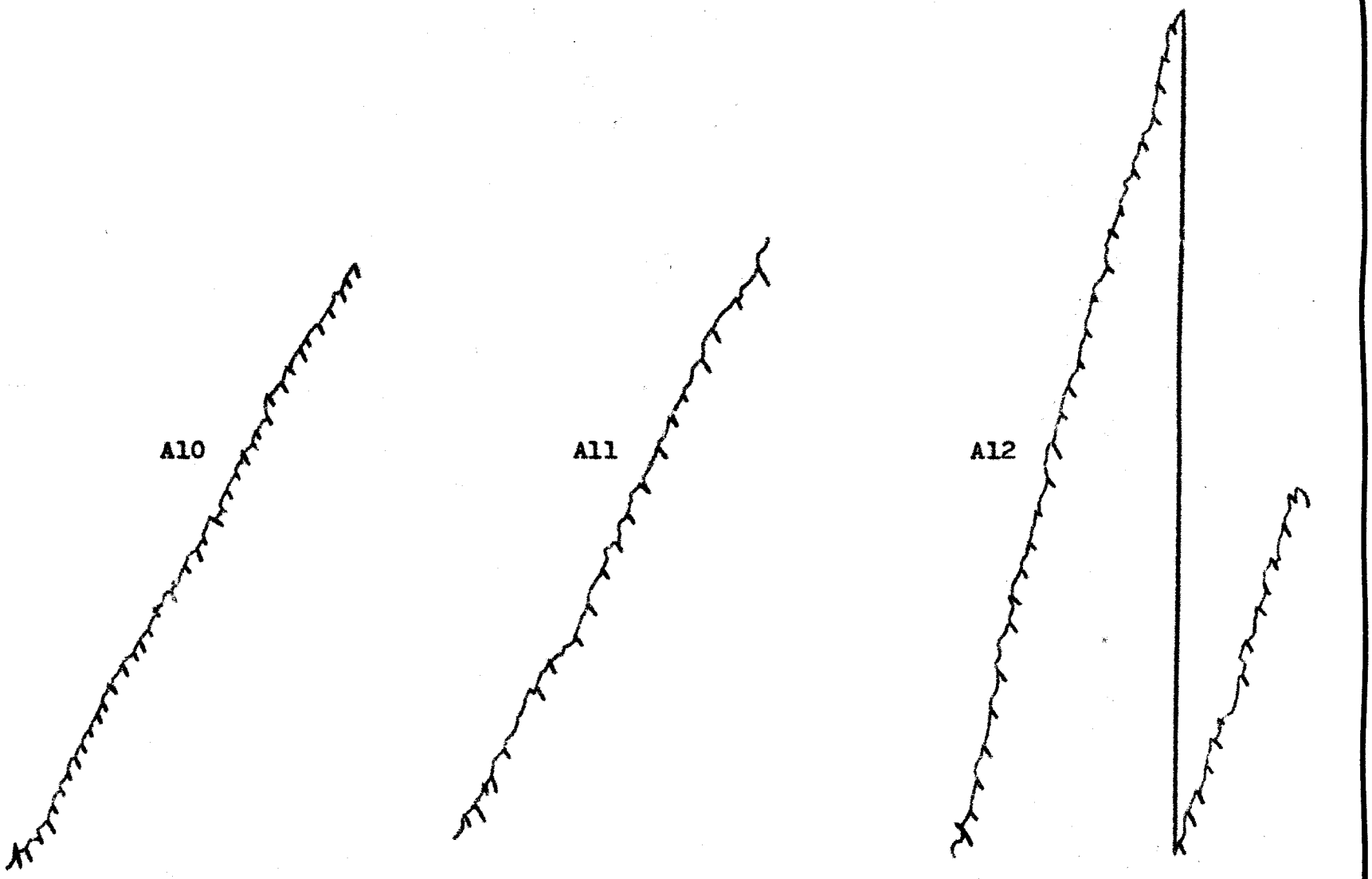


Fig. 6. Cumulative records, A10 through A12, for Subject A under the conditions noted.

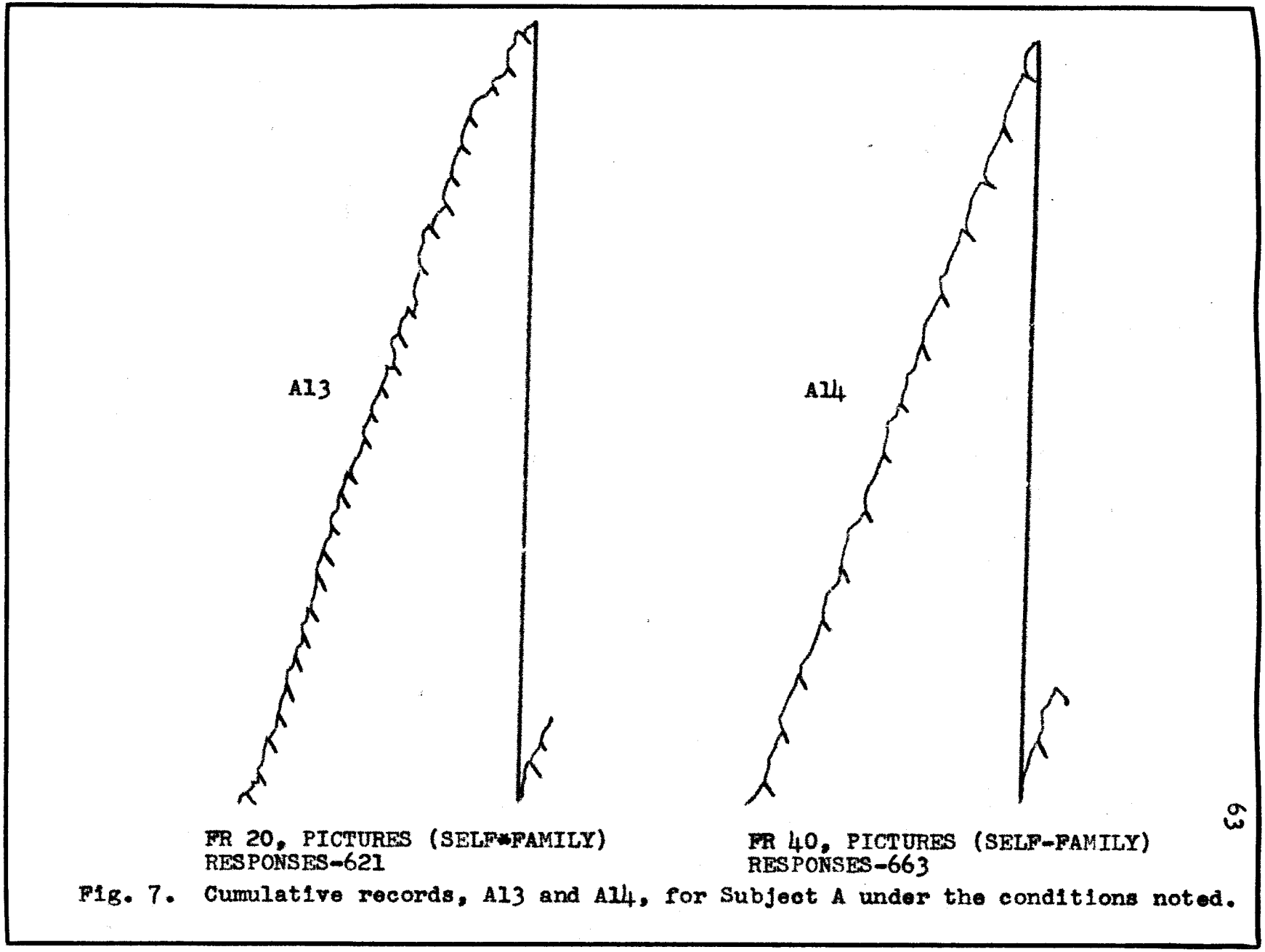


Fig. 7. Cumulative records, A13 and A14, for Subject A under the conditions noted.

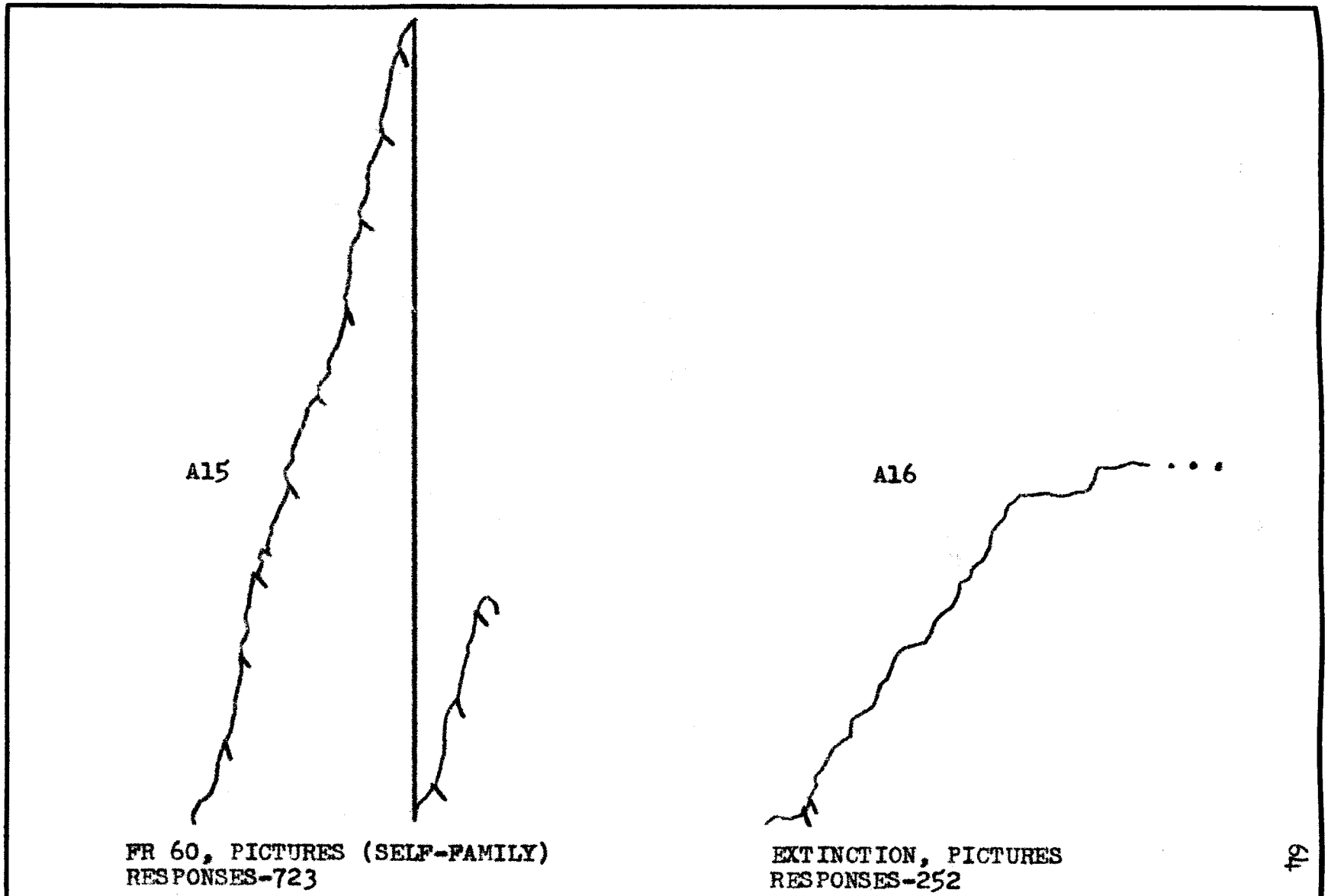


Fig. 8. Cumulative records, A15 and A16, for Subject A under the conditions noted.

It was possible to increase the ratio to FR 40 and then to FR 60 with continued consistent and smooth performance. When marbles were first presented as reinforcers the subject performed well for two or three sessions. However, with higher FR ratios, it was impossible to maintain a consistently high performance. There was a sharp drop during B15.

Responses per minute ranged, for marbles, from 27.9 to 57.7, and for pictures, from 56.8 to 72.5.

Subject C, a four year old boy with a mental age of 3-10 and an I.Q. of 96, was tested using marbles first and then pictures as reinforcers, Table 3 indicates the number of responses for the experimental sessions and the difference in percentage of responses made between the reinforcers. Figure 16 shows the difference between individual sessions. This subject was the only one who performed, during one session, at a lower rate for pictures than for marbles. However, this occured only one time and the difference was only four responses. Generally, Subject C had a more consistent rate and performance for pictures as did the two previous subjects. He performed significantly better ($p < .01$) for pictures and made an average of 37 per cent more responses than for marbles. The pictures of the subject and his family were employed during C5. As with the other subjects, this resulted in a sustained increase in rate of response.

Table 2

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject B

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	564	FR 10	725	22.3
2	FR 10	477	FR 10	635	9.3
3	FR 20	491	FR 20	568	13.8
4	FR 20	418	FR 20	570	26.7
5	FR 20	279	FR 20	705	60.5
6			FR 20	579	
7			FR 20	605	
8			FR 40	581	
9			FR 60	650	
Average		465.8		702	
Percentage of the Difference of Average Number of Responses Between Marbles and Pictures					33.7

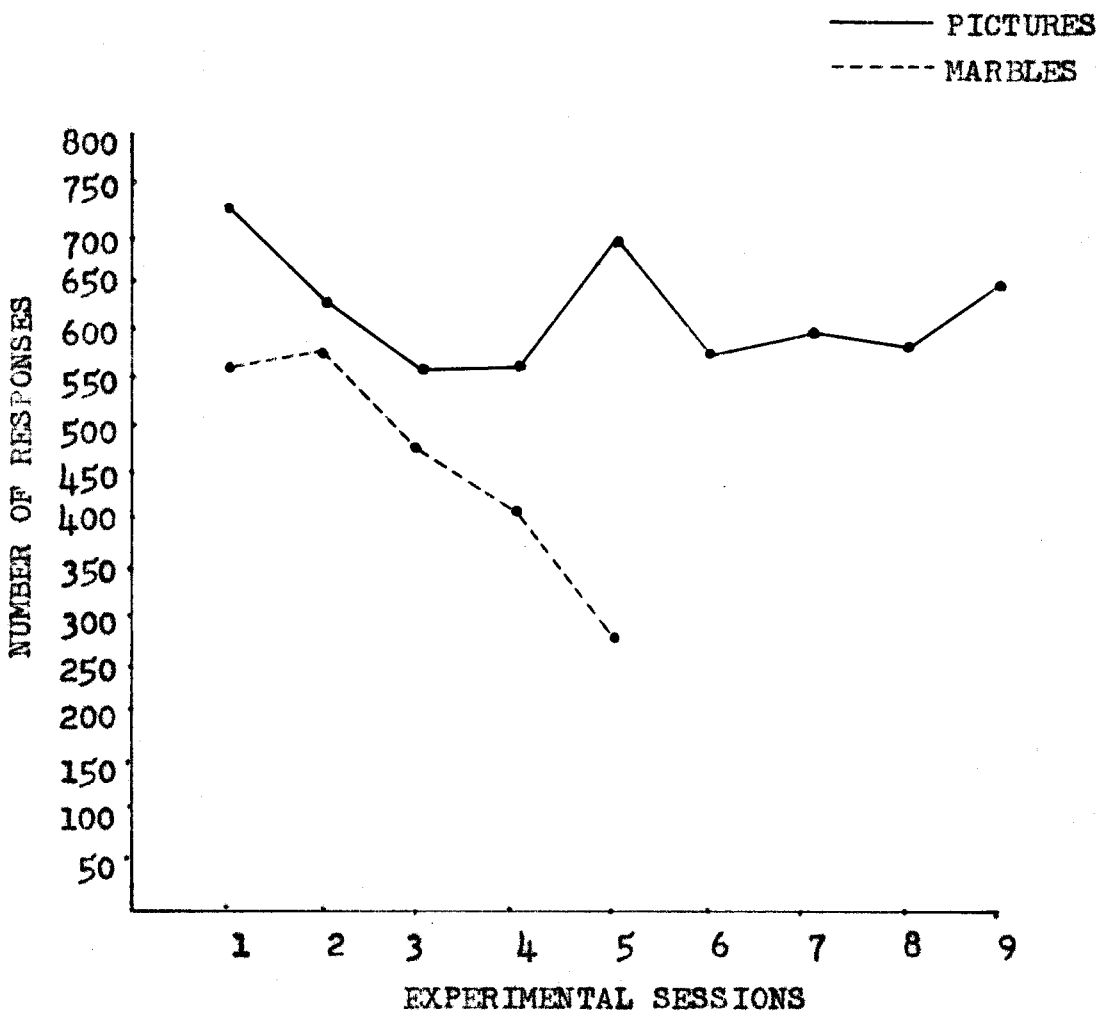
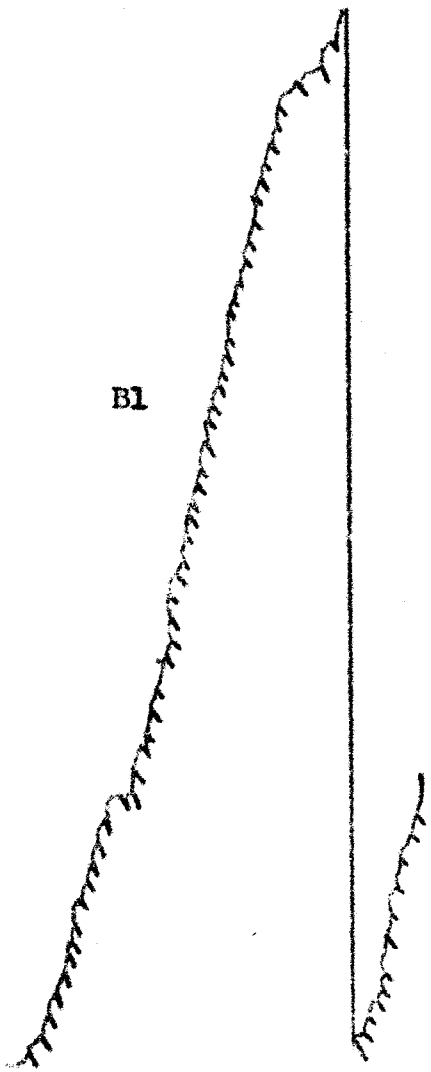
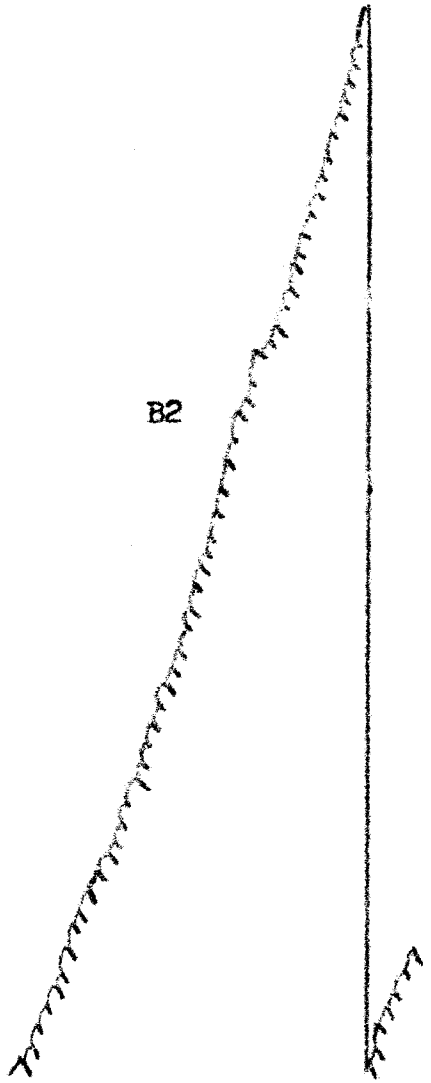


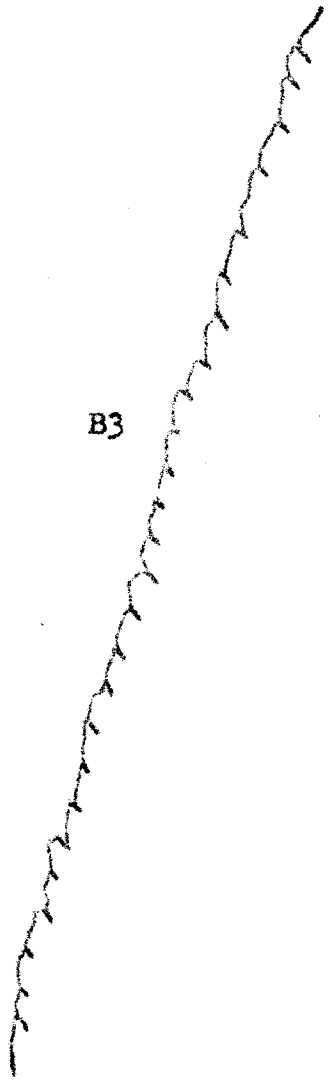
Fig. 9. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject B.



FR 10, PICTURES (ANIMAL)
RESPONSES-725



FR 10, PICTURES (ANIMAL)
RESPONSES-635



FR 20, PICTURES (ANIMAL)
RESPONSES-568

Fig. 10. Cumulative records, B1 through B3, for Subject B under the conditions noted.

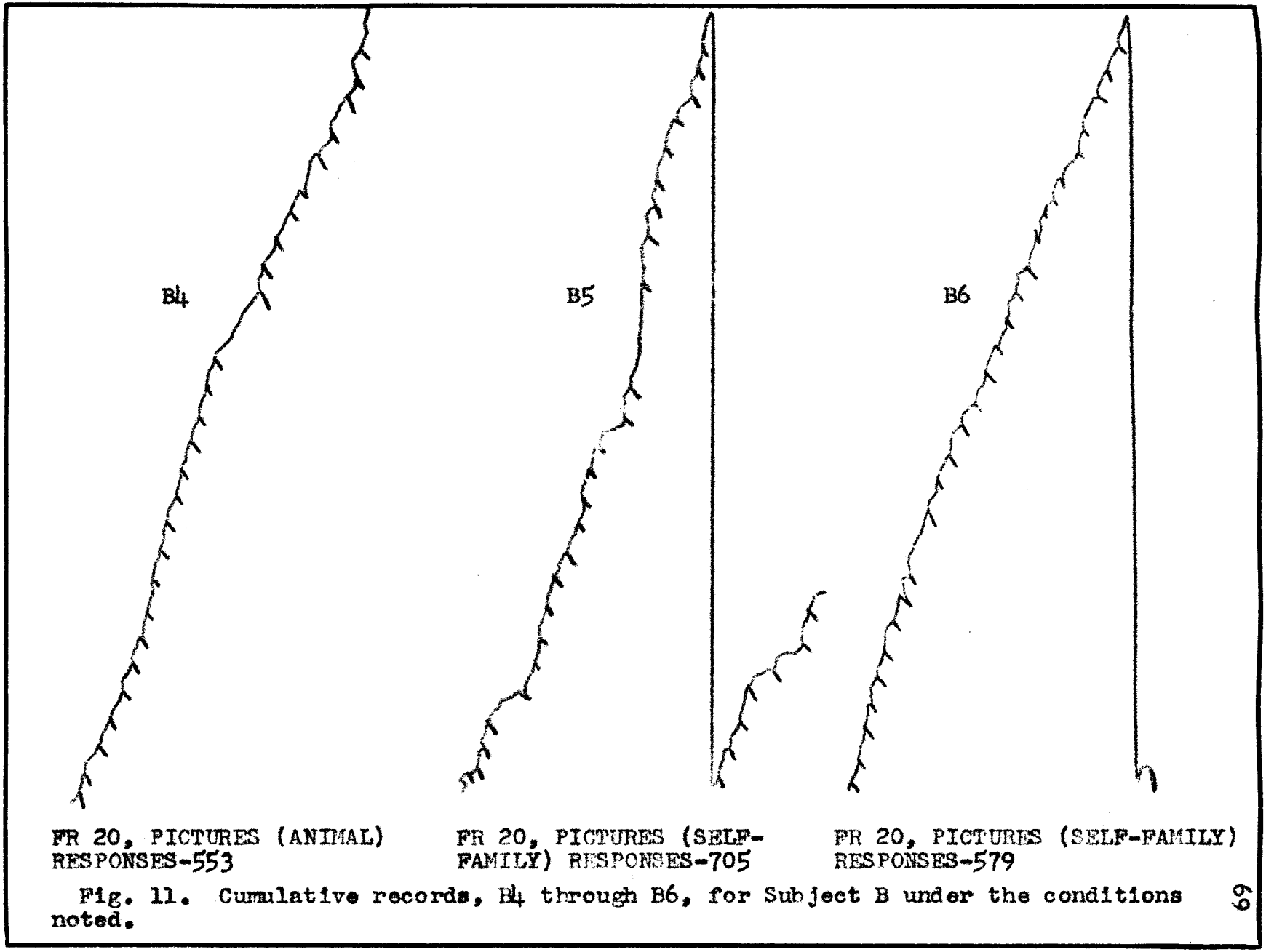
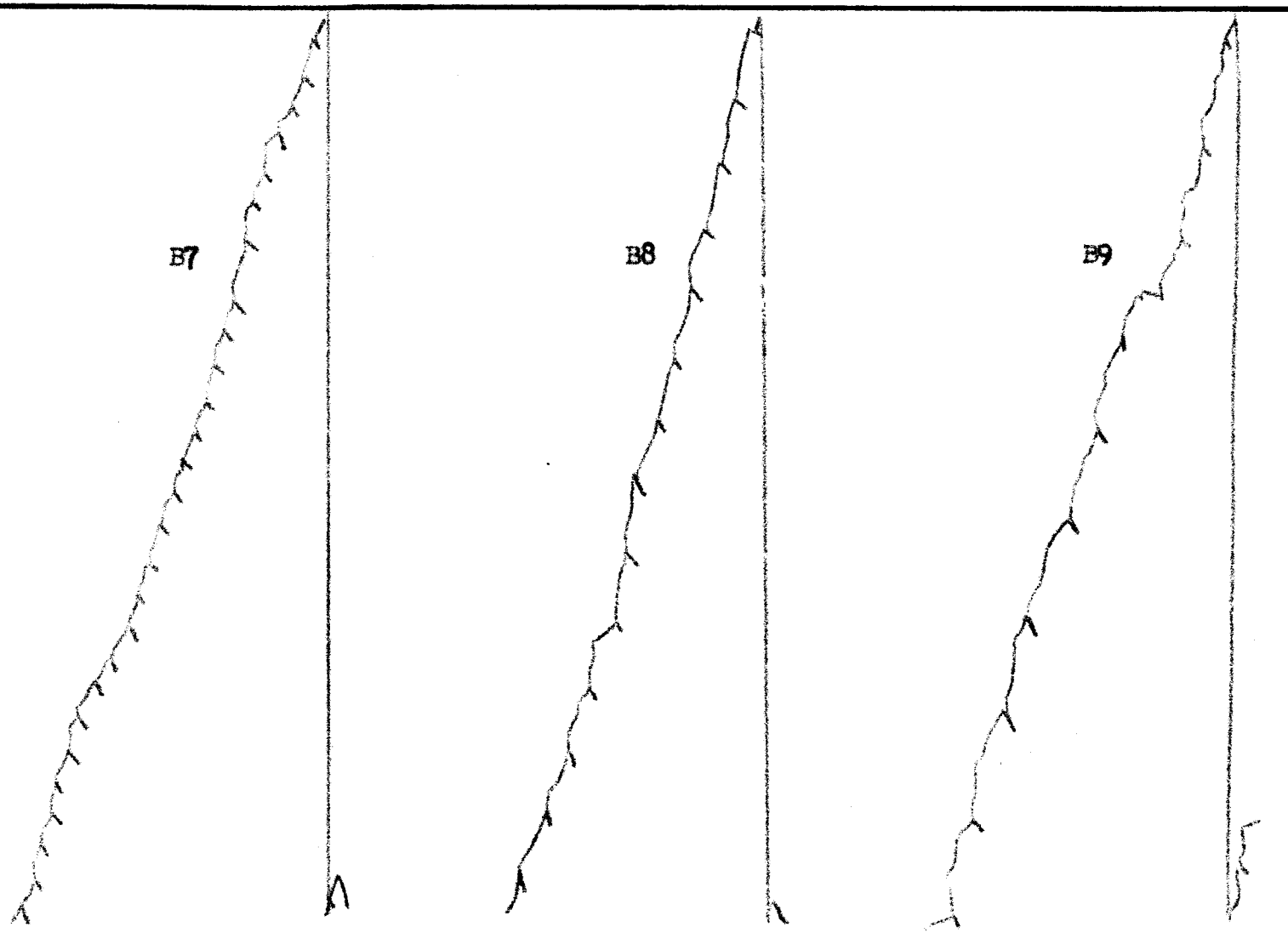


Fig. 11. Cumulative records, B4 through B6, for Subject B under the conditions noted.

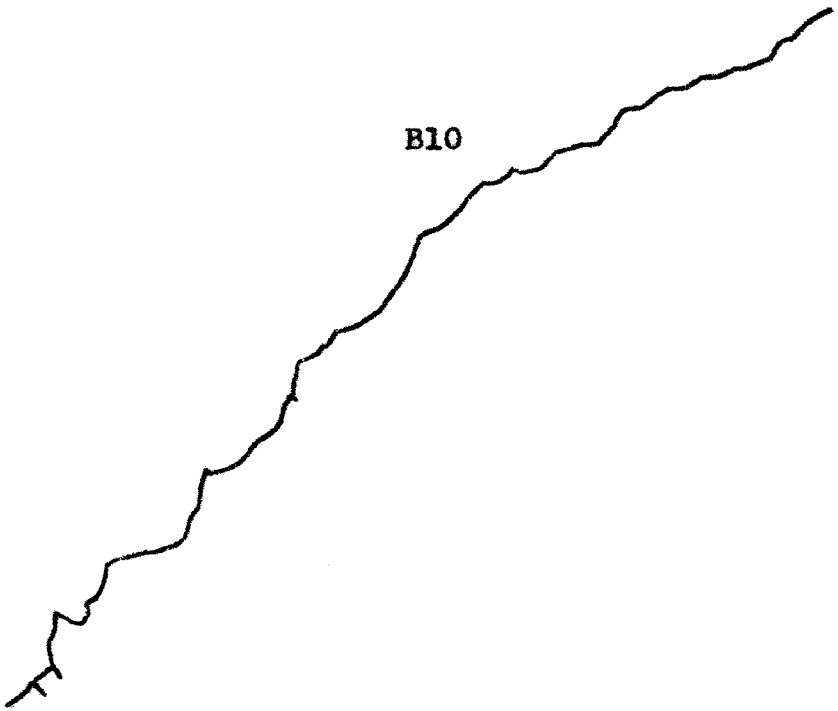


FR 20-PICTURES (SELF-FAMILY) RESPONSES-605

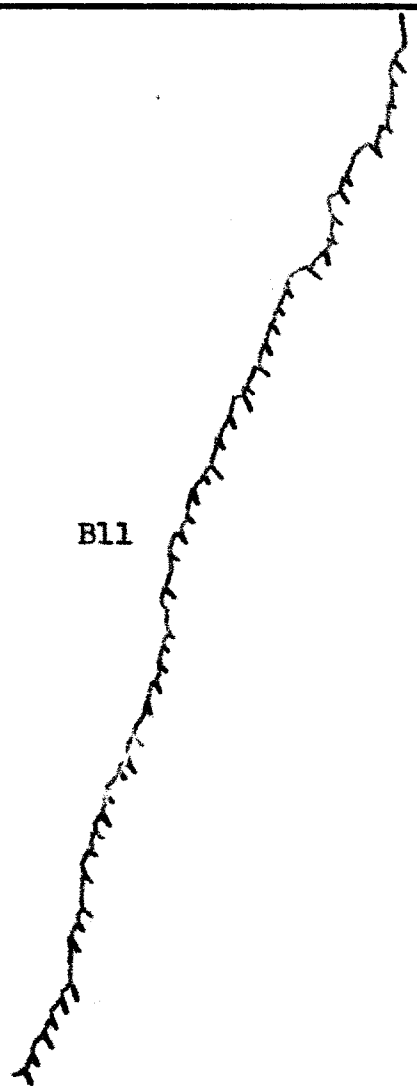
FR 40, PICTURES (SELF-FAMILY) RESPONSES-581

FR 60, PICTURES (SELF-FAMILY, RESPONSES-650

Fig. 12. Cumulative records, B7 through B9, for Subject B under the conditions noted.

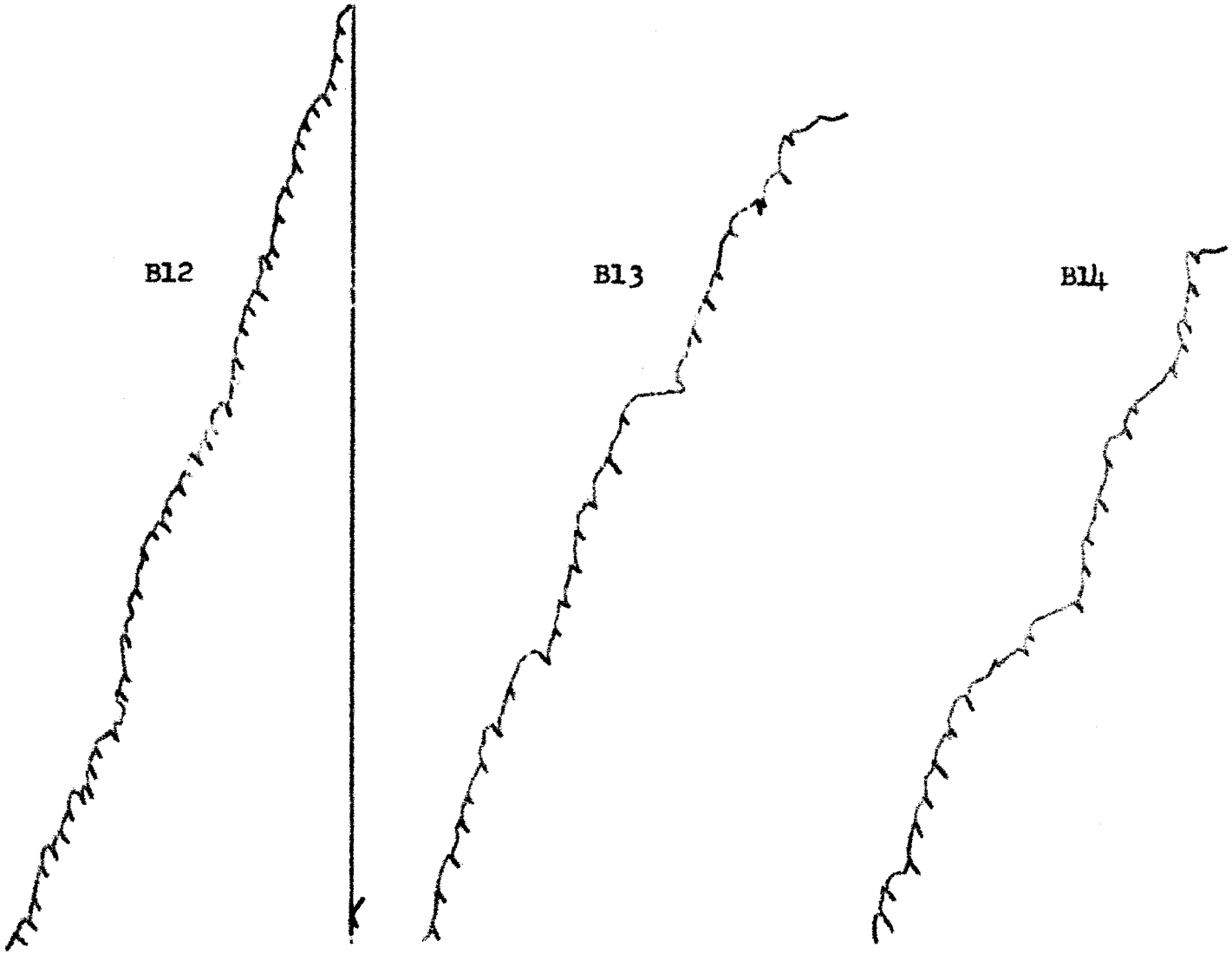


EXTINCTION, PICTURES
RESPONSES-344



FR 10, MARBLES
RESPONSES-564

Fig. 13. Cumulative records, B10 and B11, for Subject B under the conditions noted.



FR 10, MARBLES
RESPONSES-577

FR 20, MARBLES
RESPONSES-491

FR 20, MARBLES
RESPONSES-418

Fig. 14. Cumulative records, B12 through B14, for subject B under the conditions noted.

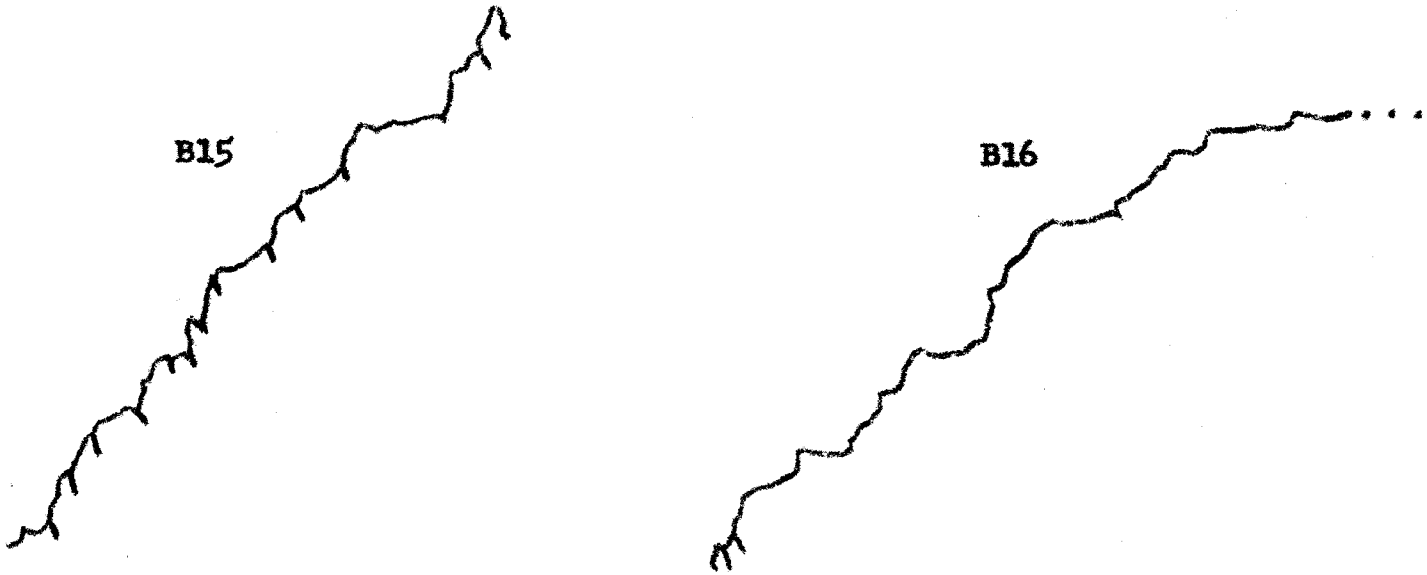


Fig. 15. Cumulative records, B15 and B16, for Subject B under the conditions noted.

Both subjects A and B were observed to perform at a steady rate at FR 60. Both were gradually raised to this level through FR 10, FR 20, and FR 40. In the case of Subject C it was decided to attempt to go directly from FR 20 to FR 60 in order to investigate the subject's reaction to so large an increase. Record C13 (page 81) shows momentary erratic responding but soon gains consistency. Responses per minute averaged for marbles 21.5 to 42.9 and for pictures 48.8 to 61.4.

Subject D was tested using pictures then marbles as reinforcers. Her chronological age was 4-5, mental age 4-4, and I.Q. 98. Table 4 indicates that this subject made an average of 62 per cent more responses for pictures than for marbles, a highly significant difference ($p<.001$). Figure 22 illustrates the difference between individual sessions.

Records D1 through D8 show the consistency and regularity of responses characterized by most of the records based on picture reinforcers. Family pictures were first used as reinforcers during D6. As with the other subjects, an immediate rise in response took place and was maintained. It can be noted on Record D9, the picture extinction trial, that at one point the subject made in excess of 60 responses without pause indicating the strong interest shown by her. Responses per minute, for marbles, varied from 12 to 40.1, and for pictures, from 57.3 to 84.

Table 3

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject C

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	416	FR 10	553	24.8
2	FR 10	429	FR 10	425	- 01.0
3	FR 20	347	FR 20	511	32.1
4	FR 20	259	FR 20	488	47.0
5	FR 20	215	FR 20	614	66.9
6			FR 20	584	
7			FR 60	531	
Average		333.2		529.4	
Percentage of the Difference of Average Number of Responses Between Marbles and Pictures					37.2

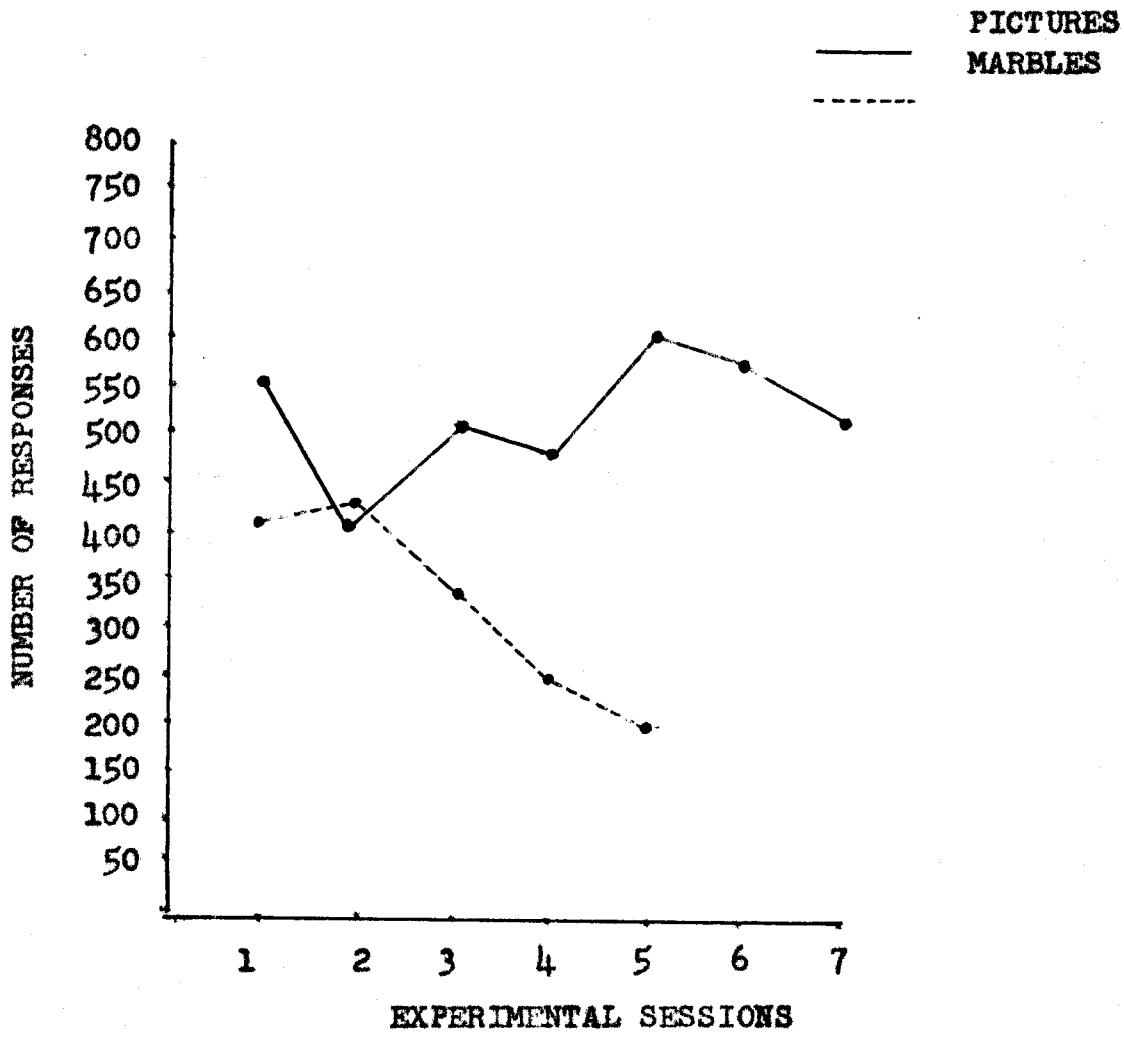
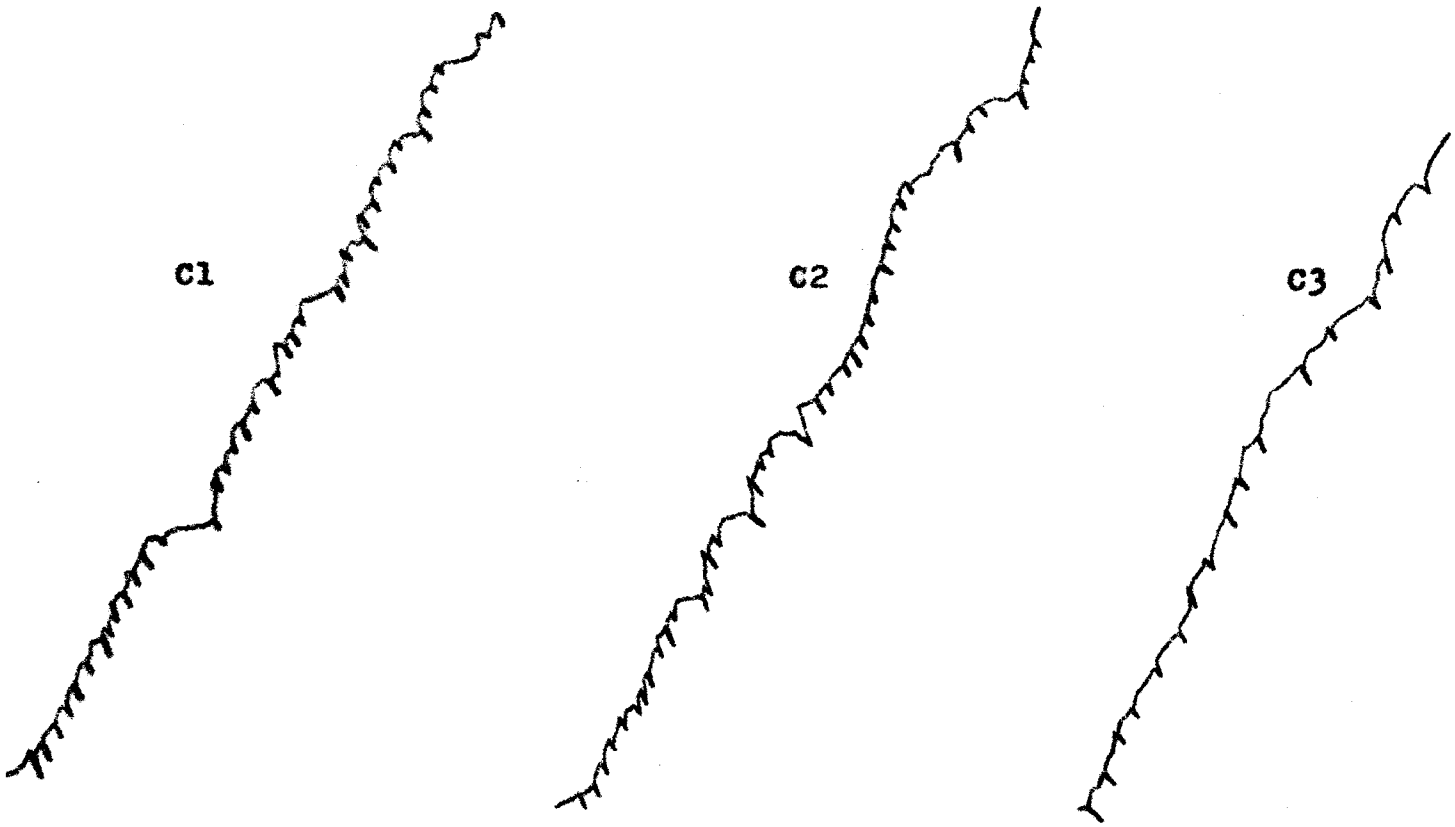


Fig. 16. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject C.



FR 10, MARBLES
RESPONSES - 416

FR 10, MARBLES
RESPONSES - 429

FR 20, MARBLES
RESPONSES - 347

Fig. 17. Cumulative records, C1 through C3, for Subject C under the conditions noted.

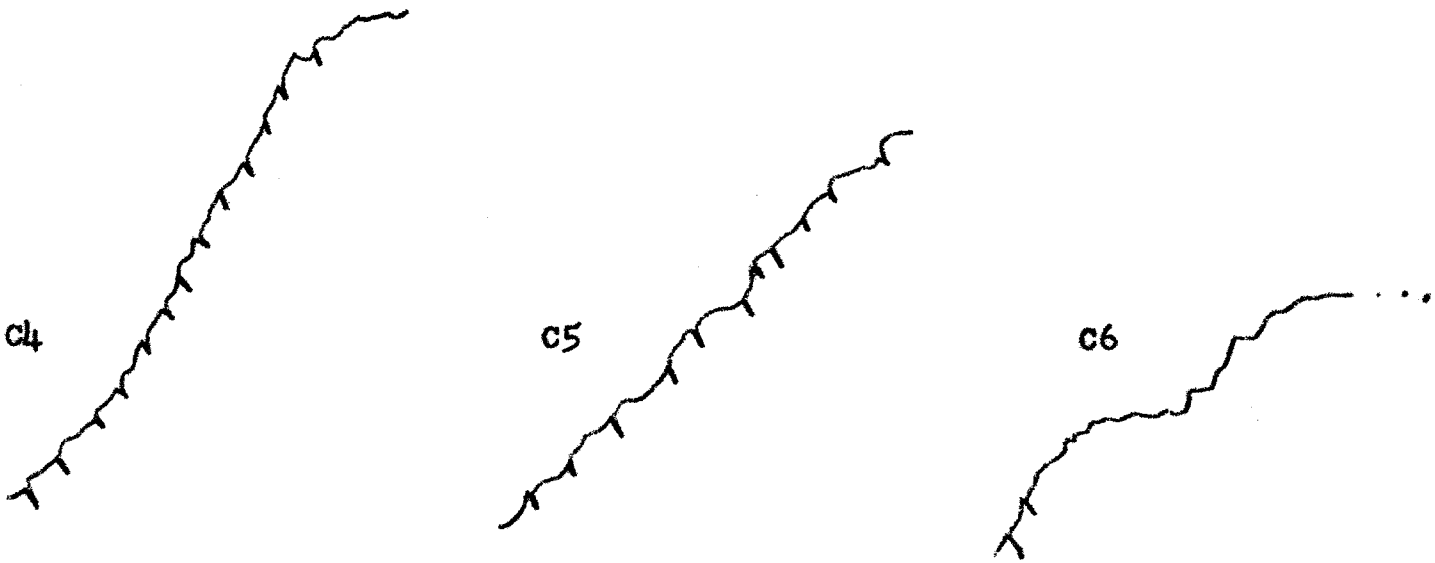


Fig. 18. Cumulative records, C4 through C6, for Subject C under the conditions noted.

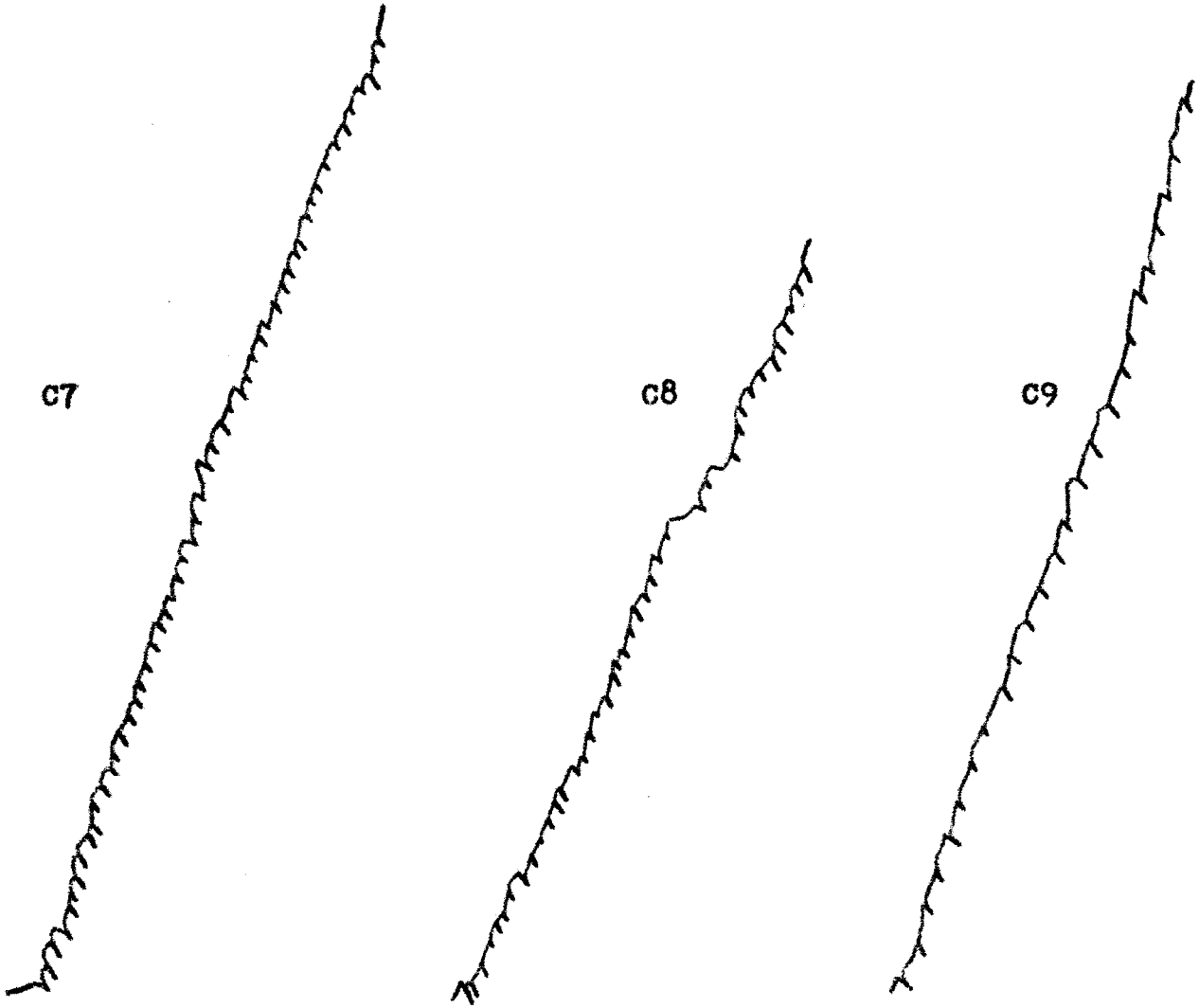
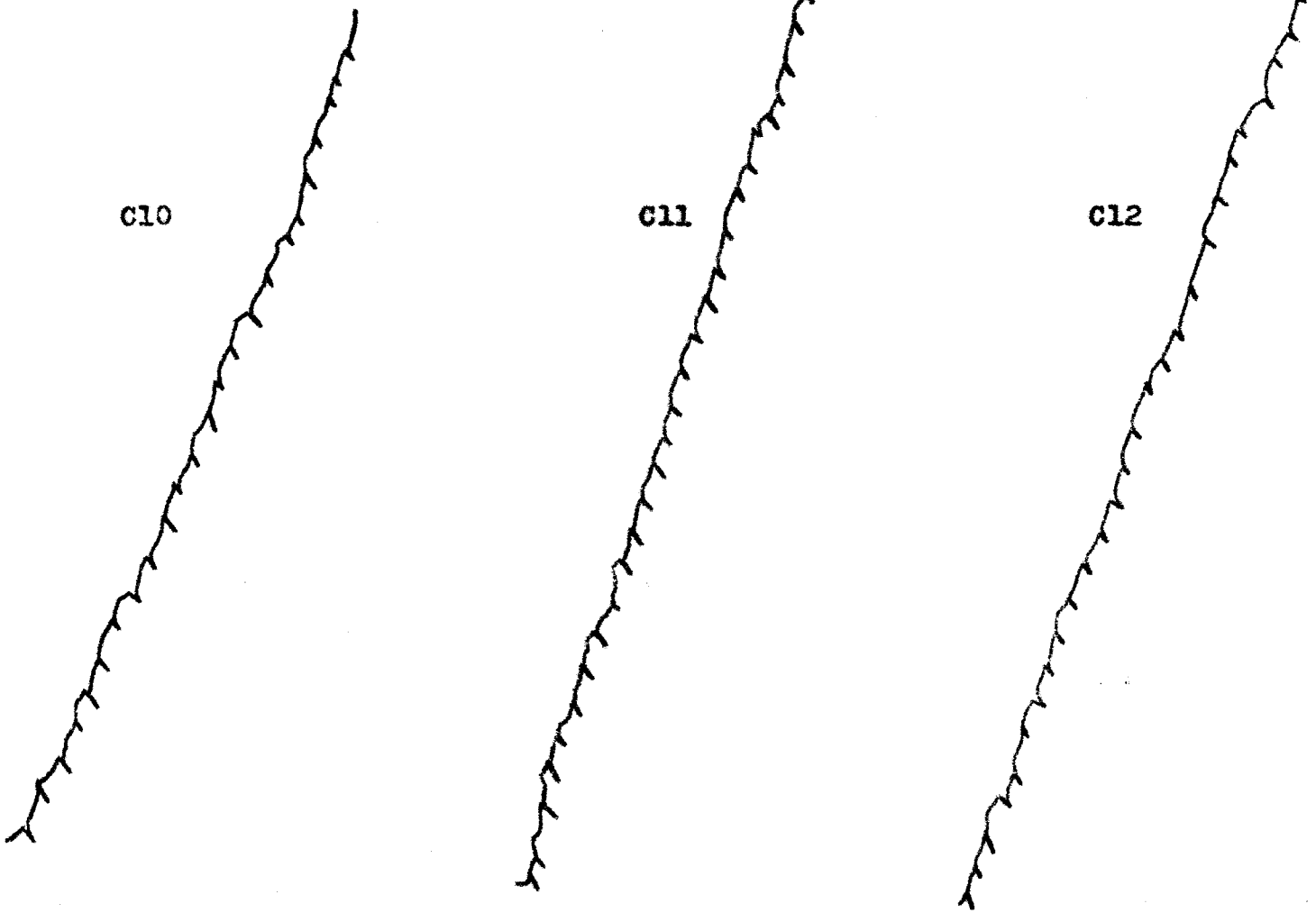


Fig. 19. Cumulative records, C7 through C9, for Subject C under the conditions noted.

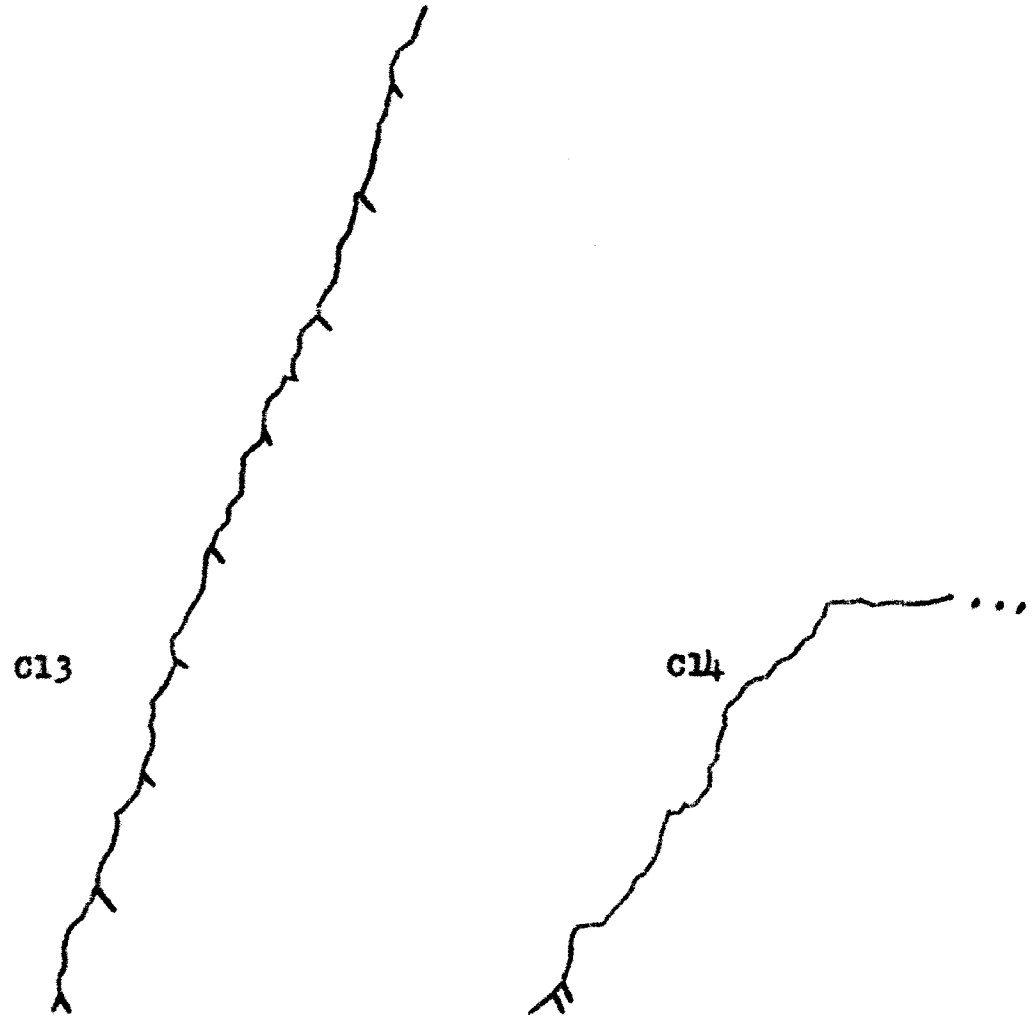


FR 20, PICTURES (ANIMAL) RESPONSES - 488

FR 20, PICTURES (SELF-FAMILY), RESPONSES - 614

FR 20, PICTURES (SELF-FAMILY), RESPONSES - 588

Fig. 20. Cumulative records, C10 through C12, for Subject C under the conditions noted.



FR 60, PICTURES (SELF - FAMILY)
RESPONSES - 531

EXTINCTION, PICTURES
RESPONSES - 216

Fig. 21. Cumulative records, C13 and C14, for Subject C under the conditions noted.

Table 4

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject D

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	401	FR 10	573	30.1
2	FR 10	363	FR 10	619	41.4
3	FR 20	218	FR 20	734	70.3
4	FR 20	253	FR 20	622	59.4
5	FR 20	208	FR 20	639	69.8
6	FR 20	120	FR 20	840	85.8
7			FR 20	725	
8			FR 40	764	
Average		260.5		689.5	
Percentage of the Difference of Average Number of Responses Between Marbles and Pictures					62.2

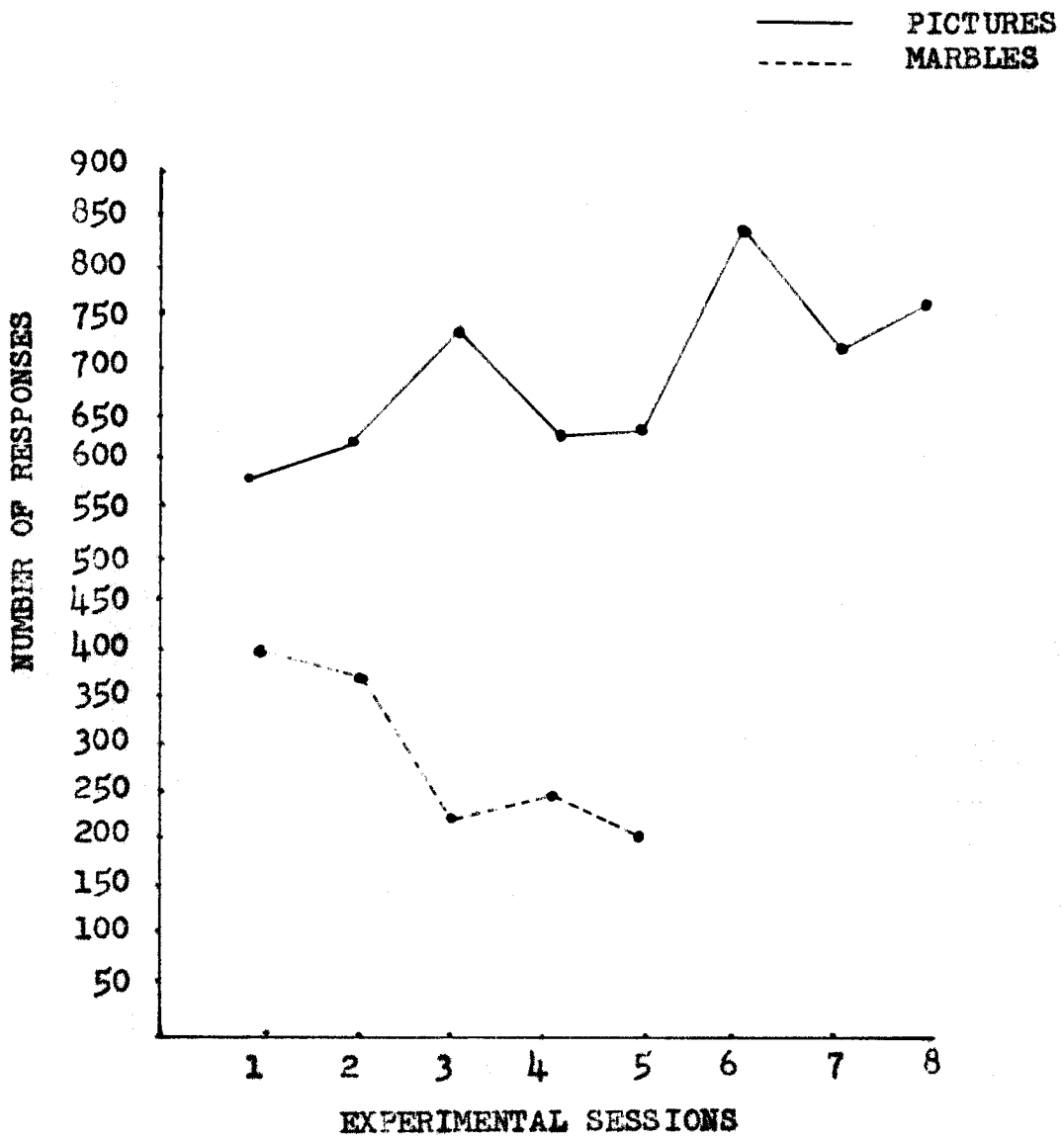


Fig. 22. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject D.

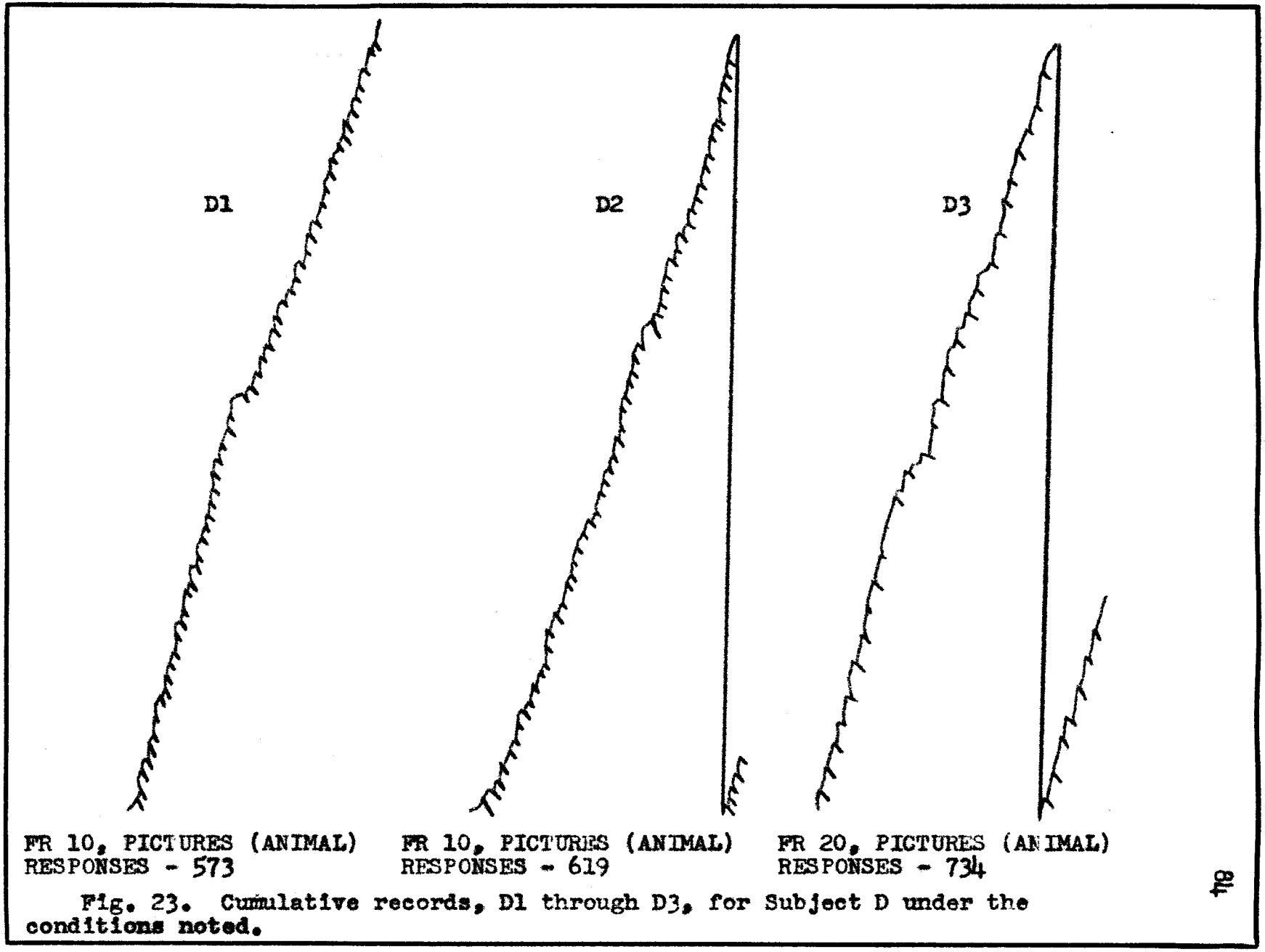


Fig. 23. Cumulative records, D1 through D3, for Subject D under the conditions noted.

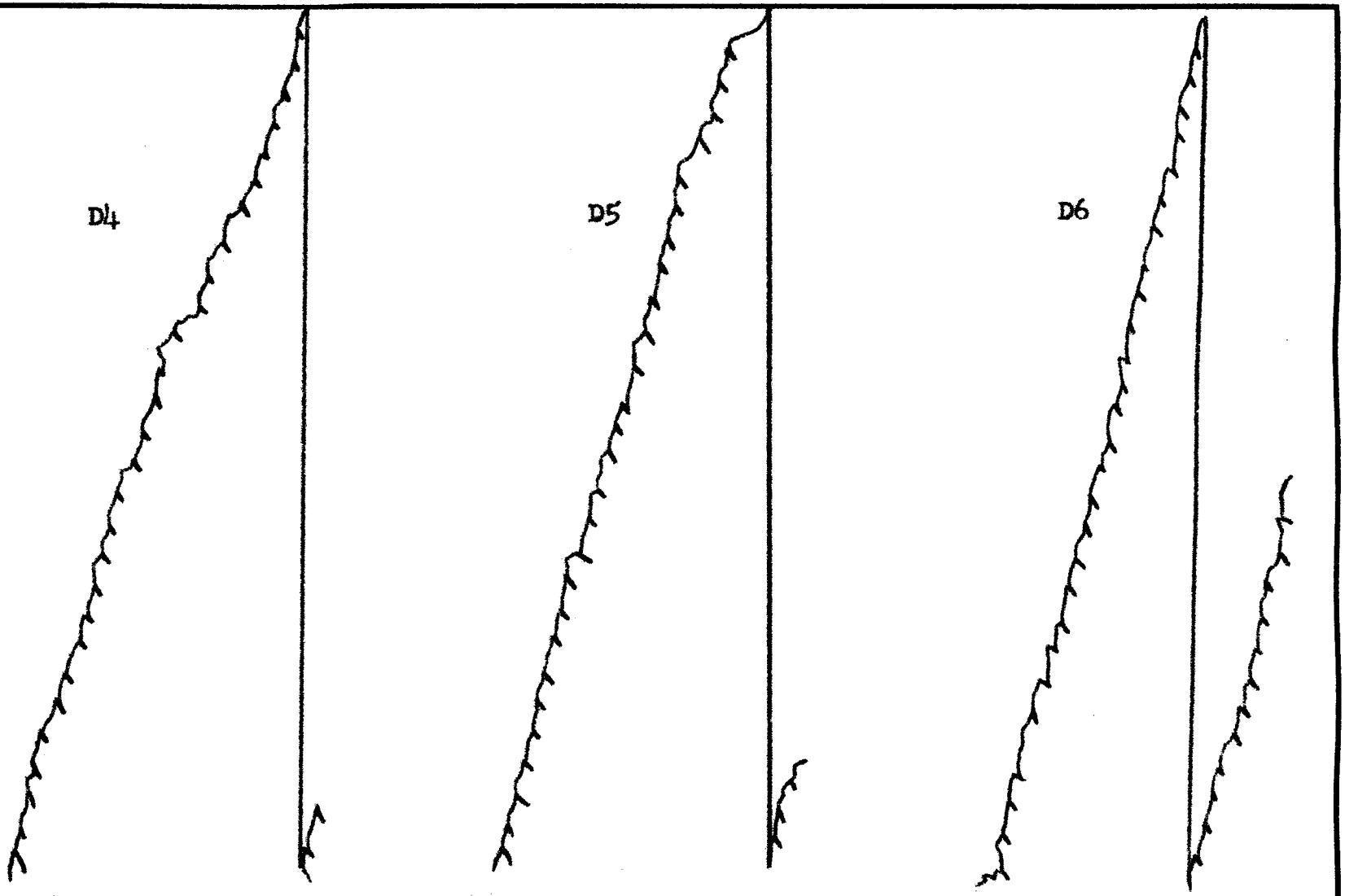


Fig. 24. Cumulative records, D4 through D6, for Subject D under the conditions noted.

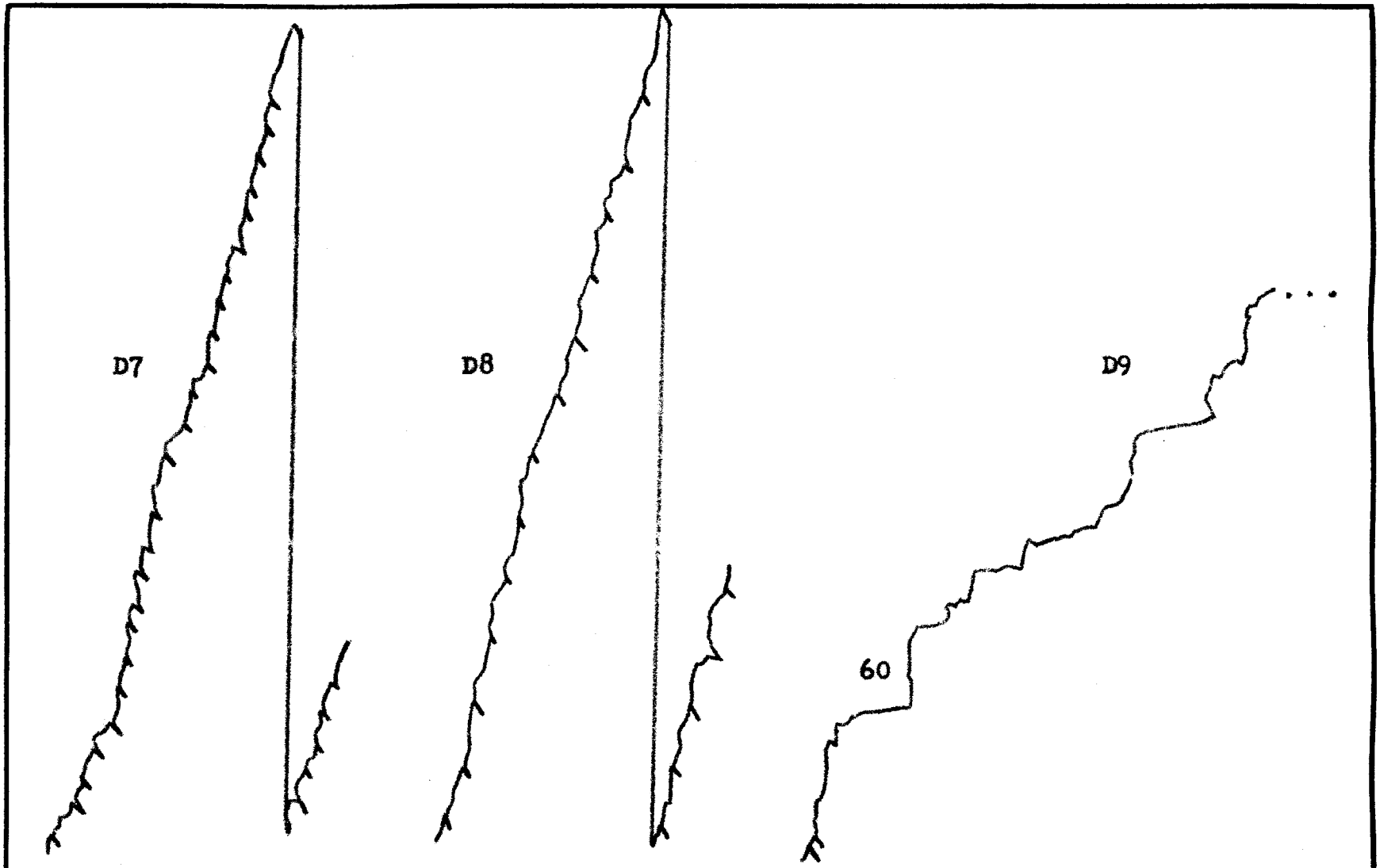


Fig. 25. Cumulative records, D7 through D9, for Subject D under the conditions noted.

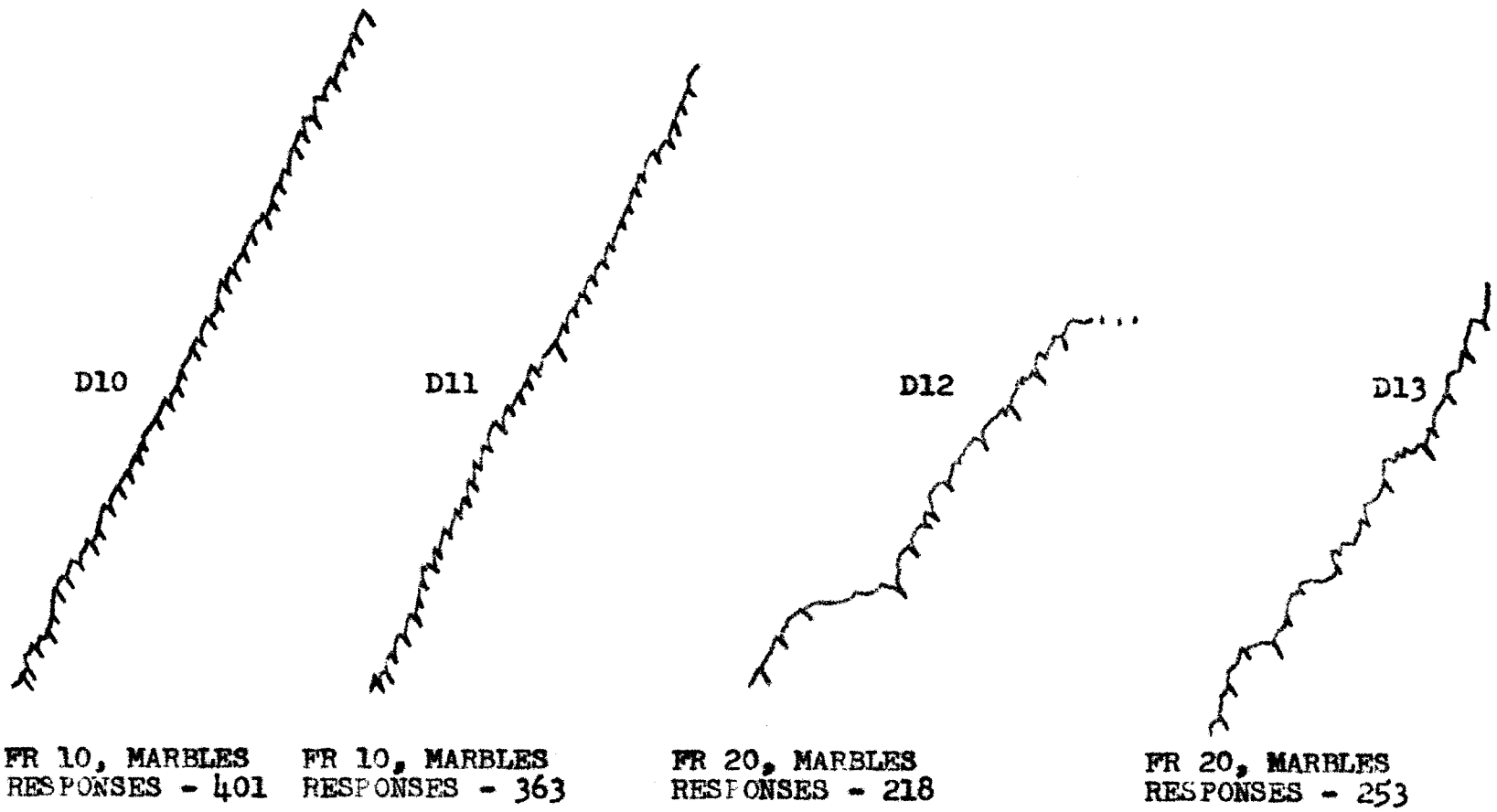
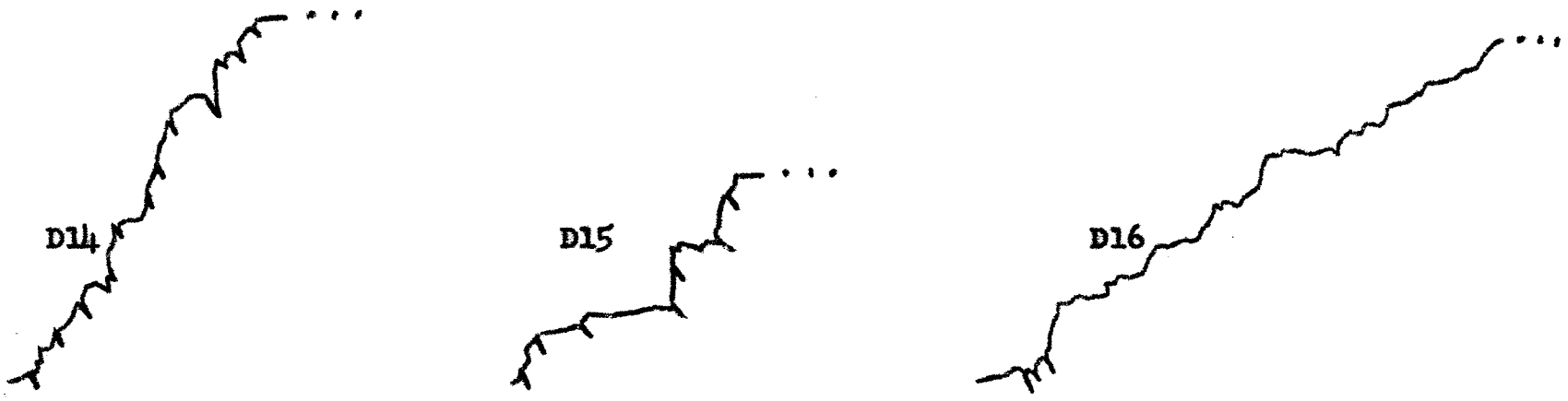


Fig. 26. Cumulative records, D10 through D13, for Subject D under the conditions noted.



FR 20, MARBLES
RESPONSES - 208

FR 20, MARBLES
RESPONSES - 120

EXTINCTION, MARBLES
RESPONSES - 191

Fig. 27. Cumulative records, D14 through D16, for Subject D under the conditions noted.

Subject E was tested using marbles first and then pictures as reinforcers. Her chronological age was 6-3, mental age 3-8, and I.Q. 60. Her performance is shown in Table 5 and Figure 28. She responded fairly regularly for the first three sessions using marbles. Then her interest dropped sharply in record E4 and only 125 responses were given during the ten minute period. Her performance with pictures as reinforcers was usually consistent and regular. She made 61 per cent more responses for pictures, a significant difference ($p < .001$). No difficulty was encountered increasing the fixed ratio from FR 20 to FR 60. The response rate continued to be steady and regular.

Subject E appeared to be somewhat withdrawn during the early sessions but smiled readily at the experimenter and others when she became accustomed to the laboratory atmosphere. Her language development was limited to short two or three word sentences. The child's mother, after viewing the apparatus, did not think that her daughter would "get the idea".

Responses per minute varied, for marbles from 9.0 to 24.7, and for pictures, from 38.9 to 59.8.

Subject F was tested using pictures then marbles as reinforcers. His chronological age was 9-7, mental age 5-9, I.Q. 61. He presented the only behavior problem in the group being somewhat difficult to control outside the experimental room. Although he responded well during each experimental session, his behavior was more intense and hostile during the testing sessions than that of

Table 5

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject E

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	247	FR 10	412	40.1
2	FR 10	223	FR 10	389	42.7
3	FR 10	261	FR 10	394	33.8
4	FR 20	125	FR 20	416	70.0
5	FR 20	149	FR 20	598	75.1
6	FR 20	90	FR 20	507	82.3
7			FR 40	562	
8			FR 60	533	
Average		182.5		476.4	
Percentage of the Difference of Average Number of Responses Between Marbles and Pictures					61.7

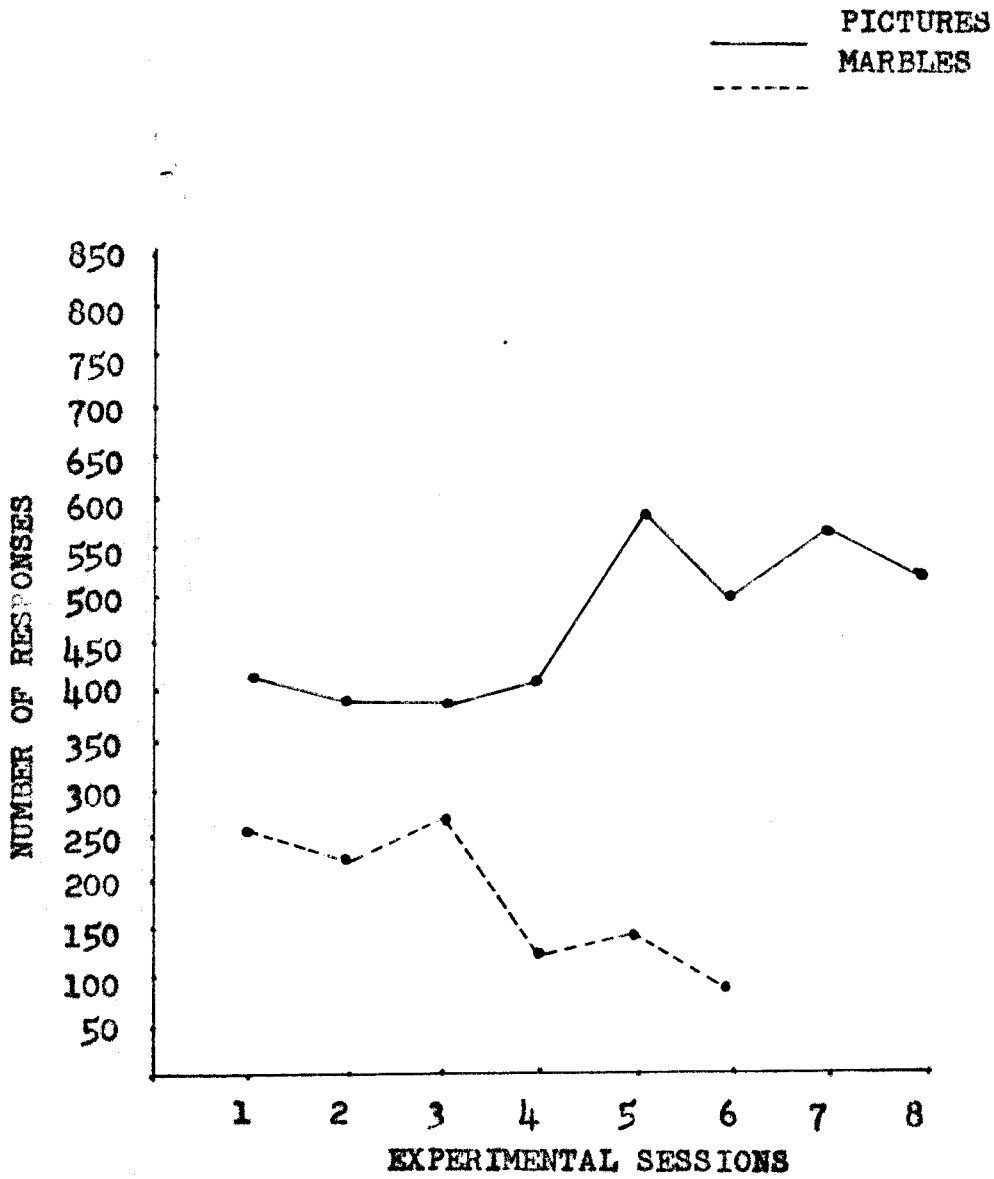
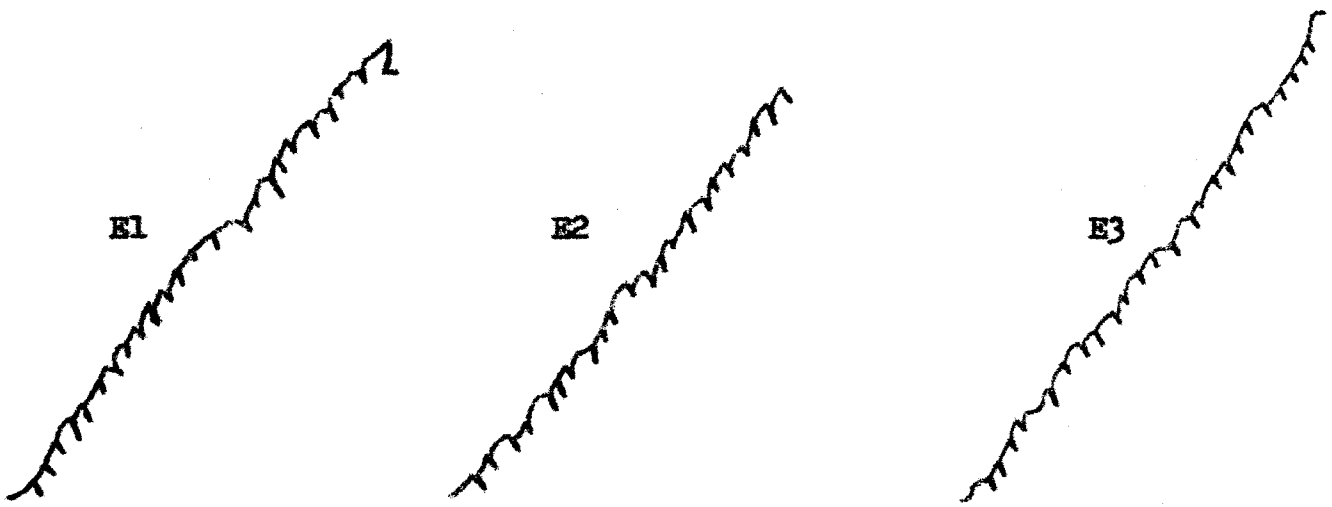


Fig. 28. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject E.

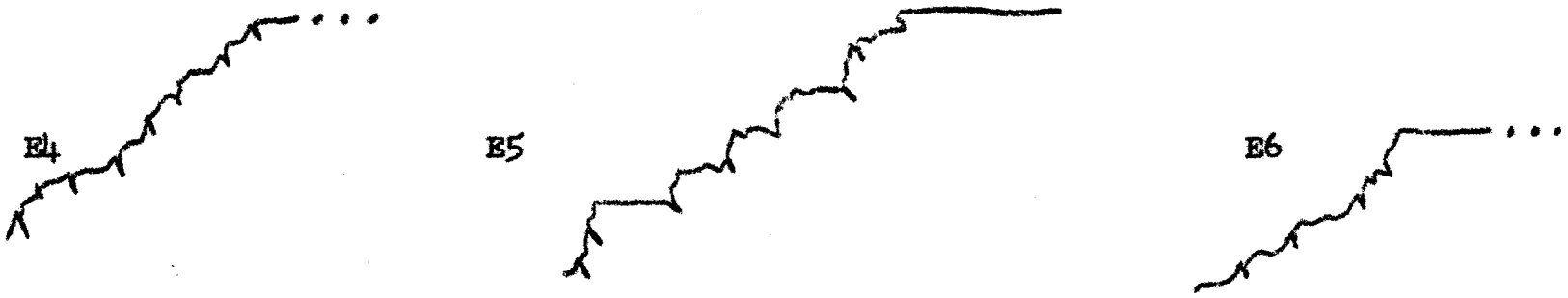


FR 10, MARBLES
RESPONSES - 247

FR 10, MARBLES
RESPONSES - 223

FR 10, MARBLES
RESPONSES - 261

Fig. 29. Cumulative records, E1 through E3, for Subject E under the conditions noted.



FR 20, MARBLES
RESPONSES - 125

FR 20, MARBLES
RESPONSES - 149

FR 20, MARBLES
RESPONSES - 90

Fig. 30. Cumulative records, E4 through E6, for Subject E under the conditions noted.

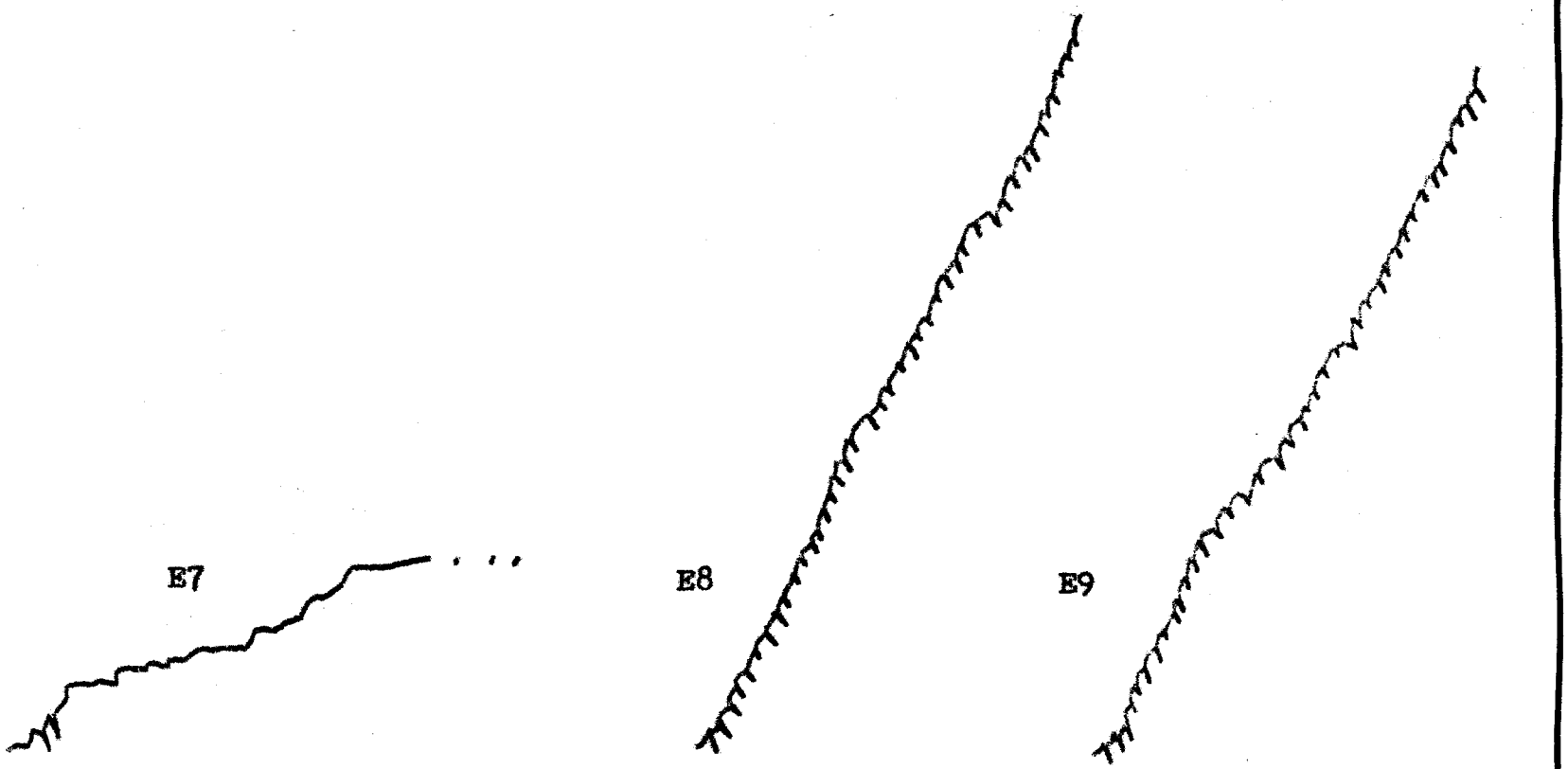
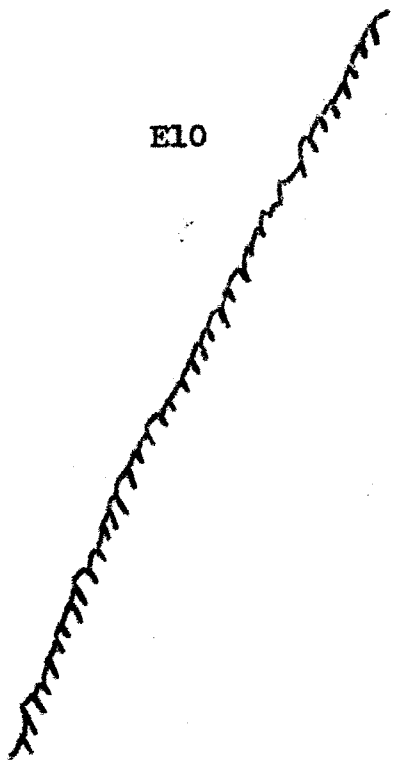
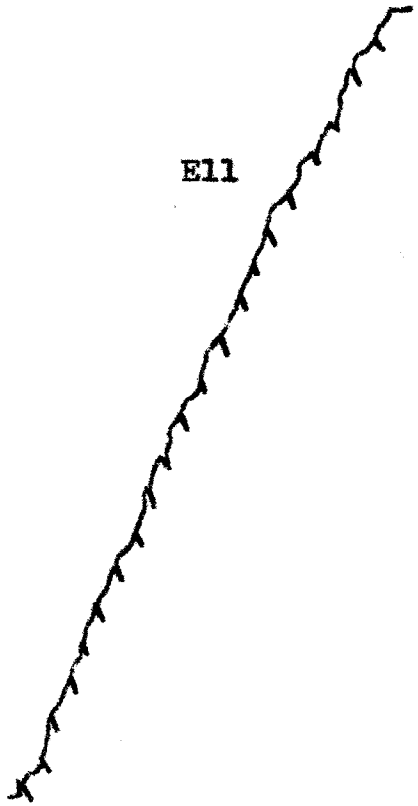
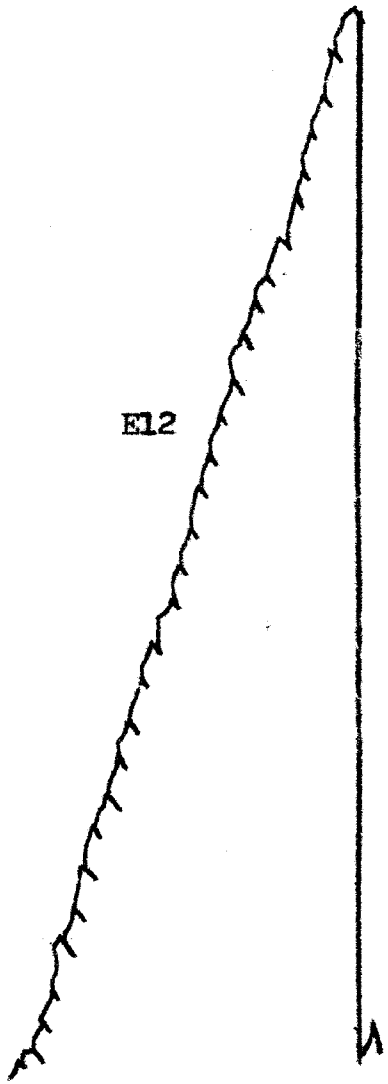


Fig. 31. Cumulative records, E7 through E9, for Subject E under the conditions noted.







FR 10, PICTURES (ANIMAL)
RESPONSES-394

FR 20, PICTURES (ANIMAL)
RESPONSES-416

FR 20, PICTURES (SELF-FAMILY)
RESPONSES-598

Fig. 32. Cumulative records, E10 through E12, for Subject E under the conditions noted.

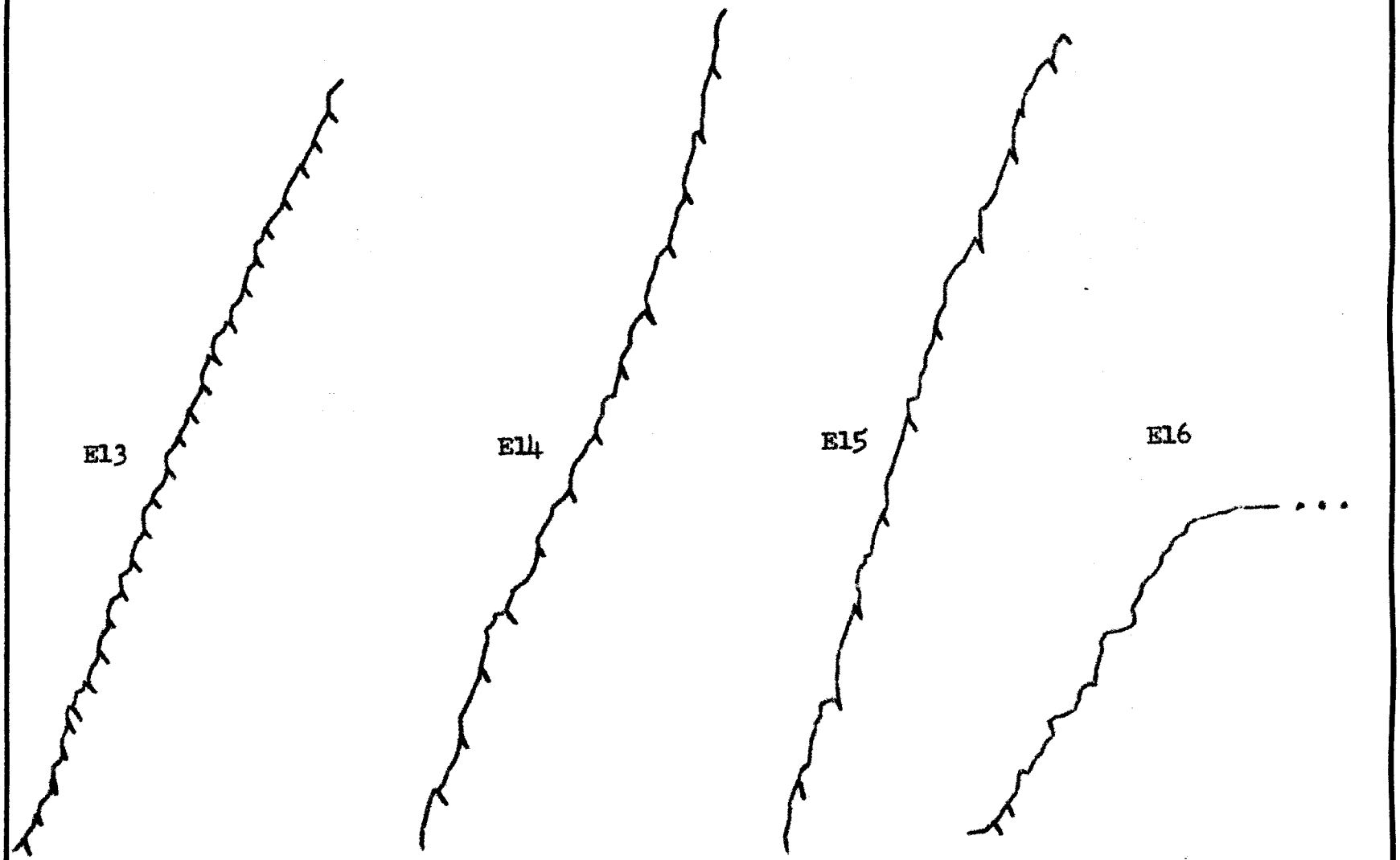


Fig. 33. Cumulative records, E13 through E16, for Subject E under the conditions noted.

the other subjects. He pounded the bar instead of pressing it. Also, he sometimes threw his marbles around the room, especially in the latter marble sessions when his interest in this reinforcer was waning. He took an intense interest in family pictures, but was the only subject who appeared to take a more noticable interest in pictures of himself as compared to other members of the family.

Fatigue played a more important factor with this child than with the other subjects. Because he hit the bar so violently, and thus expended more energy, he became tired more rapidly. When he became fatigued he frequently changed his hands and even used his elbows to press the bar.

He made 46per cent more responses for pictures than for marbles, a significant difference ($p < .01$). Table 6 and Figure 34 indicate the individual session differences between the reinforcers.

Responses per minute, for marbles, varied from 22.3 to 53.1, and for pictures, 67.1 to 75.4.

Subject G was a six year old boy with a mental age of 3-7 and an I.Q. of 57. Language development was poor consisting mostly of single words and gestures. He appeared to be a withdrawn child and was the only subject who required his mother to accompany him on every trip to the behavior laboratory. He also wanted his mother to stay with him in the experimental room

Table 6

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject F

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	508	FR 10	706	28.1
2	FR 10	531	FR 10	674	21.2
3	FR 20	423	FR 20	706	40.1
4	FR 20	281	FR 20	681	58.9
5	FR 20	289	FR 20	754	61.7
6	FR 20	223	FR 20	727	69.4
7			FR 20	671	
8			FR 40	705	
9			FR 60	739	
Average		375.7		707	
Percentage of the Difference of Average Number of Responses Between Marbles and Pictures					46.9

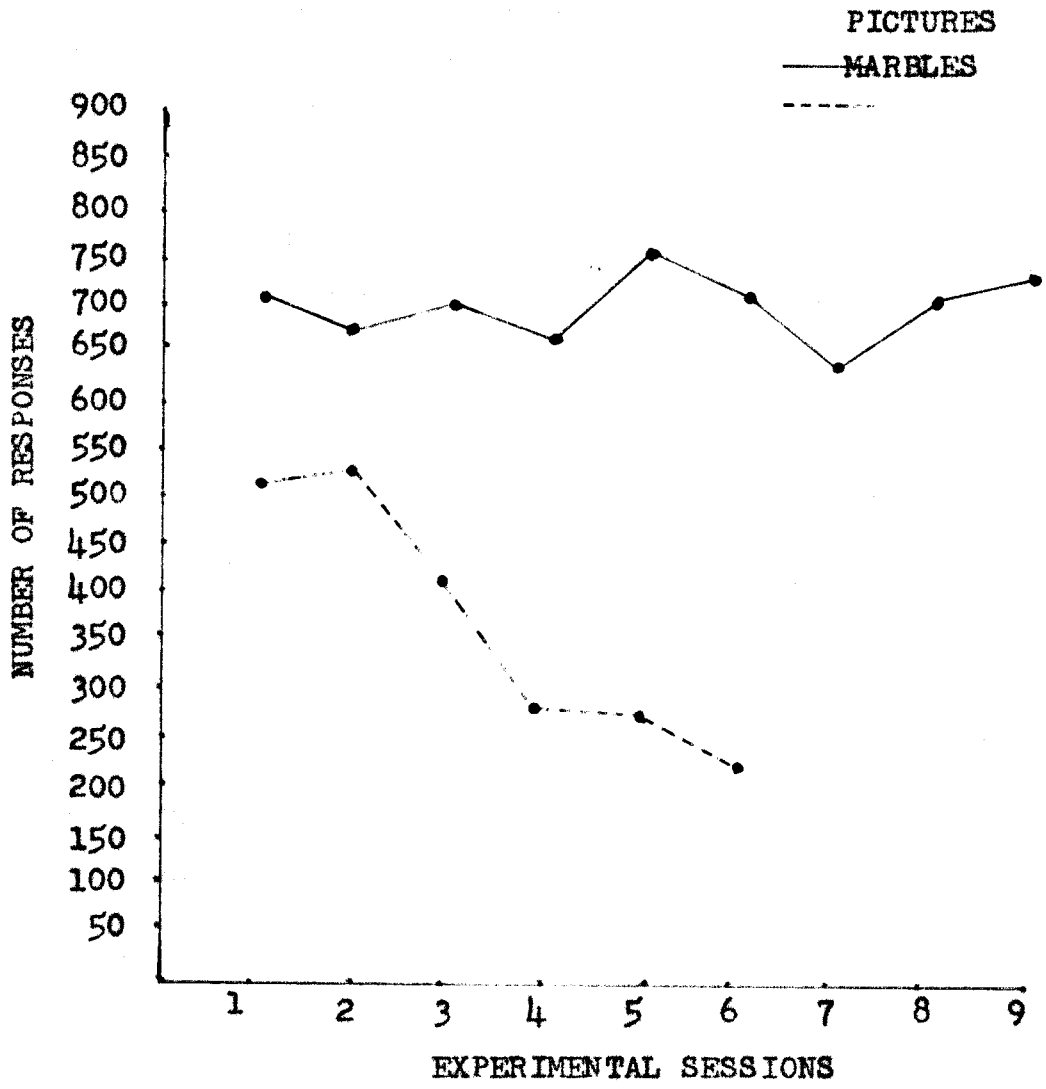
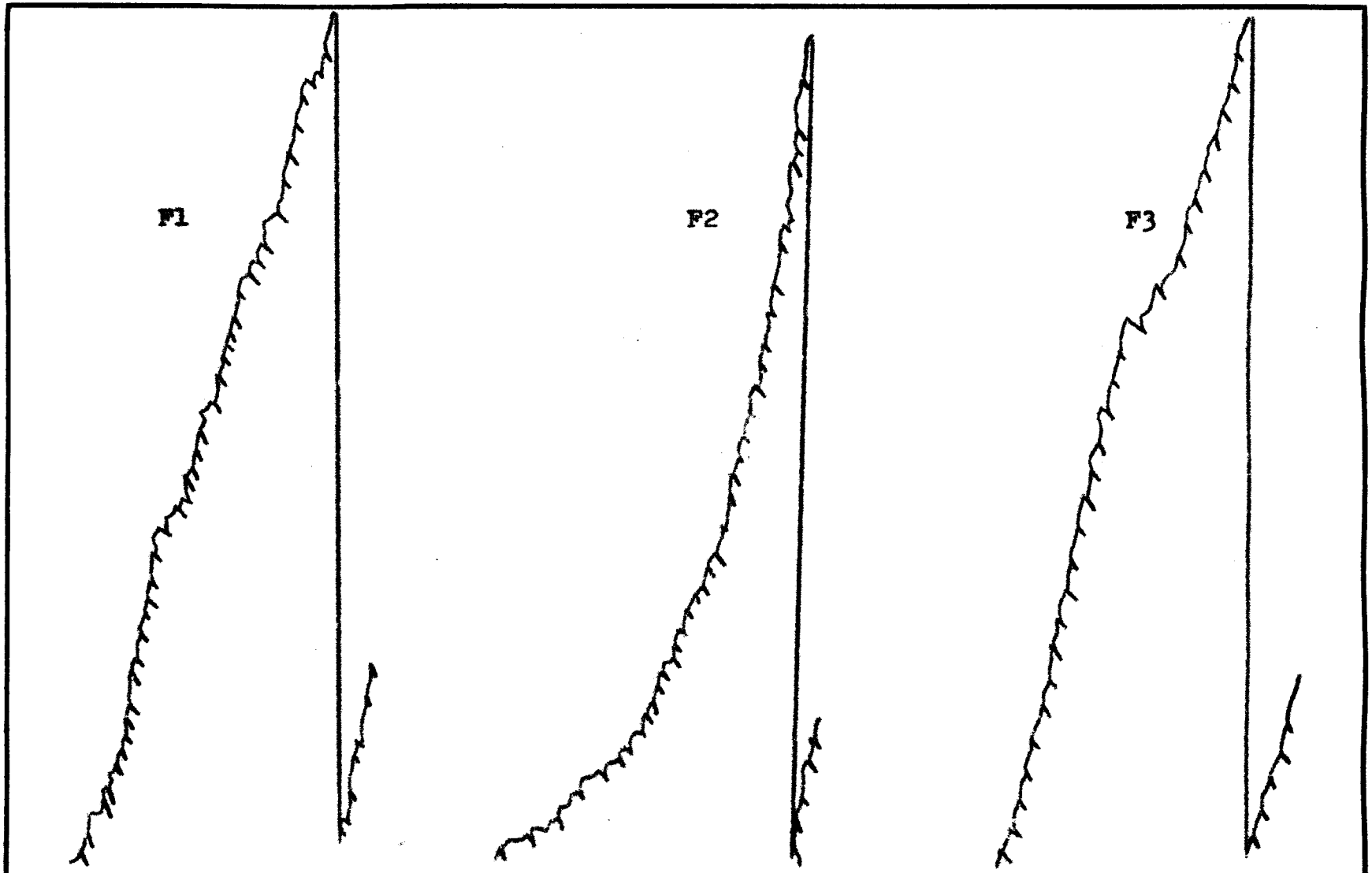


Fig. 34. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject F.



FR 10, PICTURES (ANIMAL)
RESPONSES - 706

FR 10, PICTURES (ANIMAL)
RESPONSES - 674

FR 20, PICTURES (ANIMAL)
RESPONSES - 706

Fig. 35. Cumulative records, F1 through F3, for Subject F under the conditions noted.

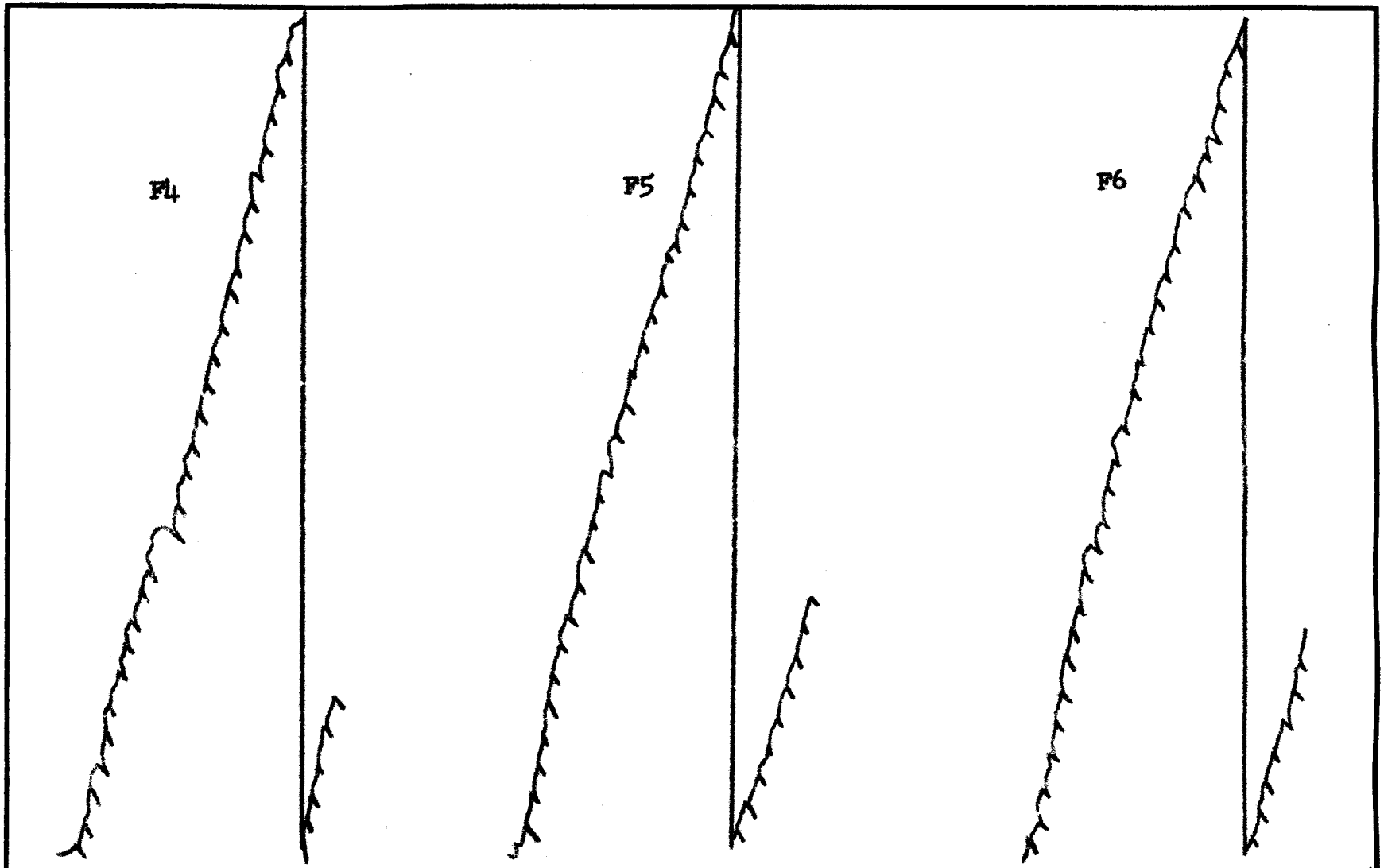
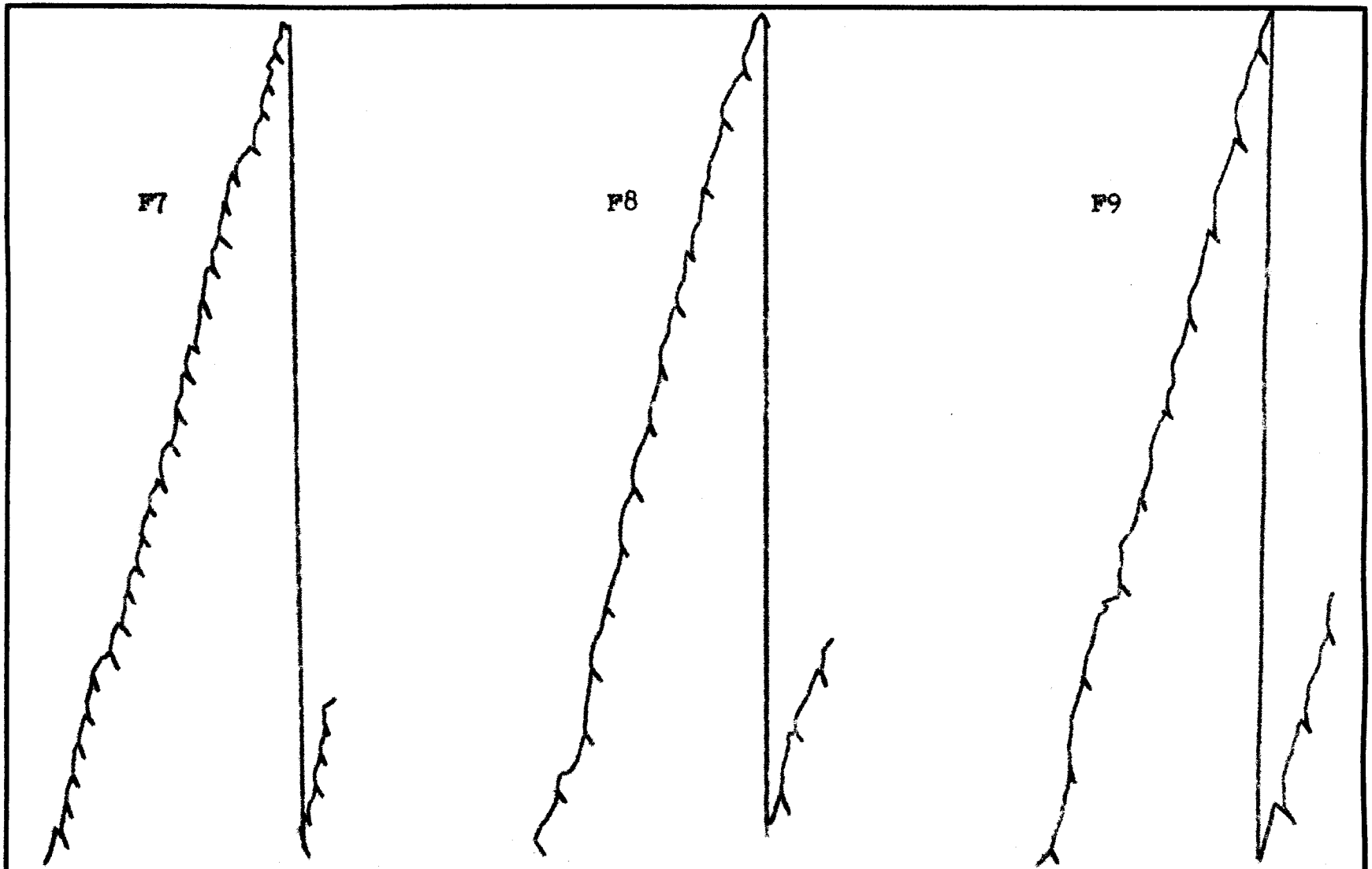


Fig. 36. Cumulative records, F4 through F6, for Subject F under the conditions noted.



FR 20, PICTURES (SELF-FAMILY), RESPONSES - 671

FR 40, PICTURES (SELF-FAMILY), RESPONSES - 705

FR 60, PICTURES (SELF-FAMILY), RESPONSES - 739

Fig. 37. Cumulative records, F7 through F9, for Subject F under the conditions noted.

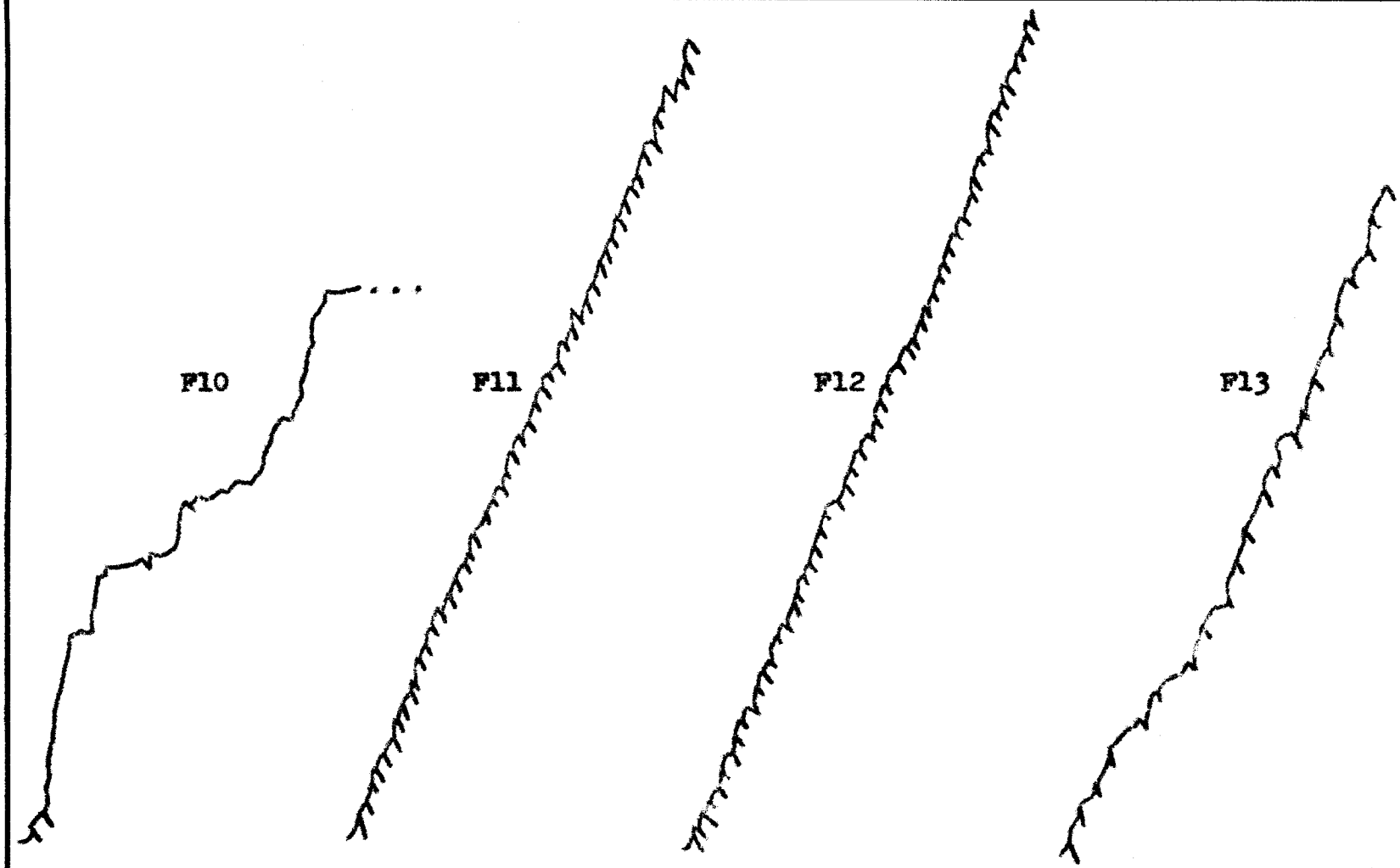


Fig. 38. Cumulative records, F10 through F13, for Subject F under the conditions noted.

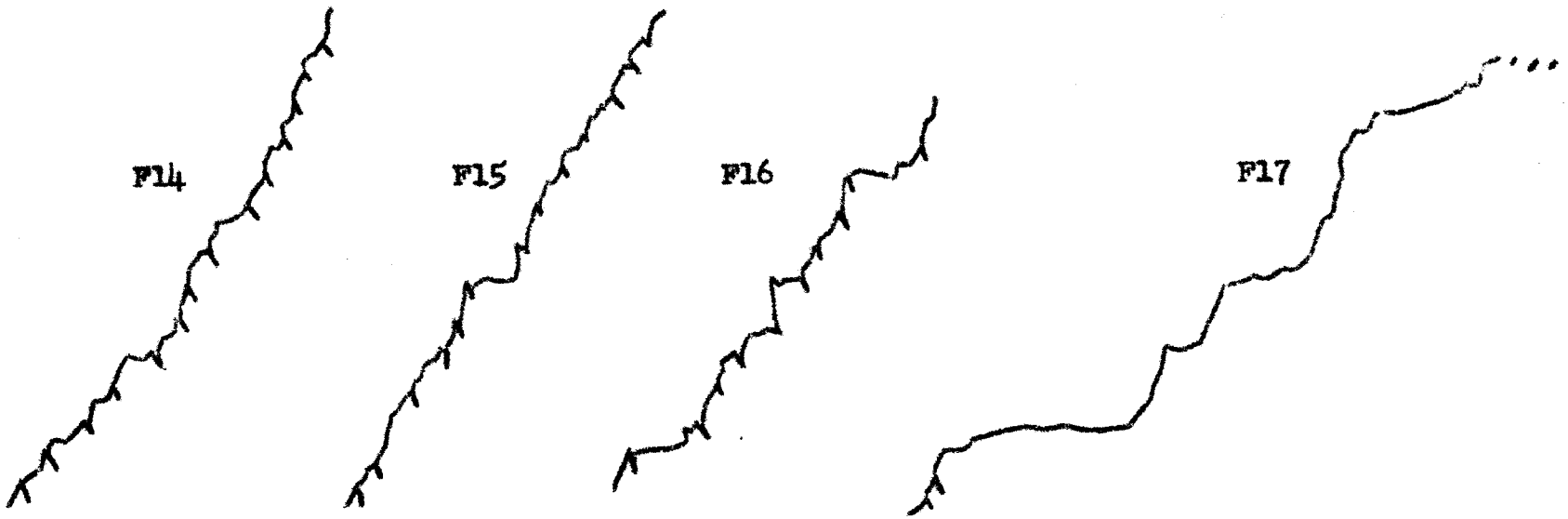


Fig. 39. Cumulative records, F14 through F17, for Subject F under the conditions noted.

but this was not permitted and the subject seemed to be able to tolerate the situation as long as the mother remained just outside the room for the duration of each session. The child's anxieties did not seem to interfere with his response to the experiment since his averages compare favorably with the other children used. Table 7 and Figure 40 show his performance.

Subject G was tested using marbles first and then pictures as reinforcers. This subject was taken from FR 20 to FR 60 without any intervening fixed ratio as was Subject C. The responding remained regular and consistent.

He had a significantly higher average rate of response for pictures than for marbles ($p < .01$). Responses per minute, for marbles, varied from 8.8 to 38.7, and for pictures, from 56.3 to 74.9.

Subject H, a seven year old girl, had a mental age of 4-0 and an I.Q. of 56. Language development was better than the other three retarded subjects. She was able to speak in simple sentences and could verbalize her desires. She presented a unique problem at the time of her first visit to the behavior laboratory. The mother had been left outside and the experimenter brought the subject into the laboratory and into the experimental room. She pointed to one of the laboratory assistants, who was wearing a white coat, and began screaming and crying. The assistant was asked to remove his coat and in a short while the subject quieted

Table 7

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject G

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	387	FR 10	633	38.9
2	FR 10	360	FR 10	563	36.1
3	FR 20	285	FR 20	641	55.6
4	FR 20	194	FR 20	599	67.6
5	FR 20	88	FR 20	749	88.3
6			FR 20	684	
7			FR 60	708	
Average		262.8		653.9	
Percentage of the Difference of Average Number of Responses Between Marbles and Pictures					59.8

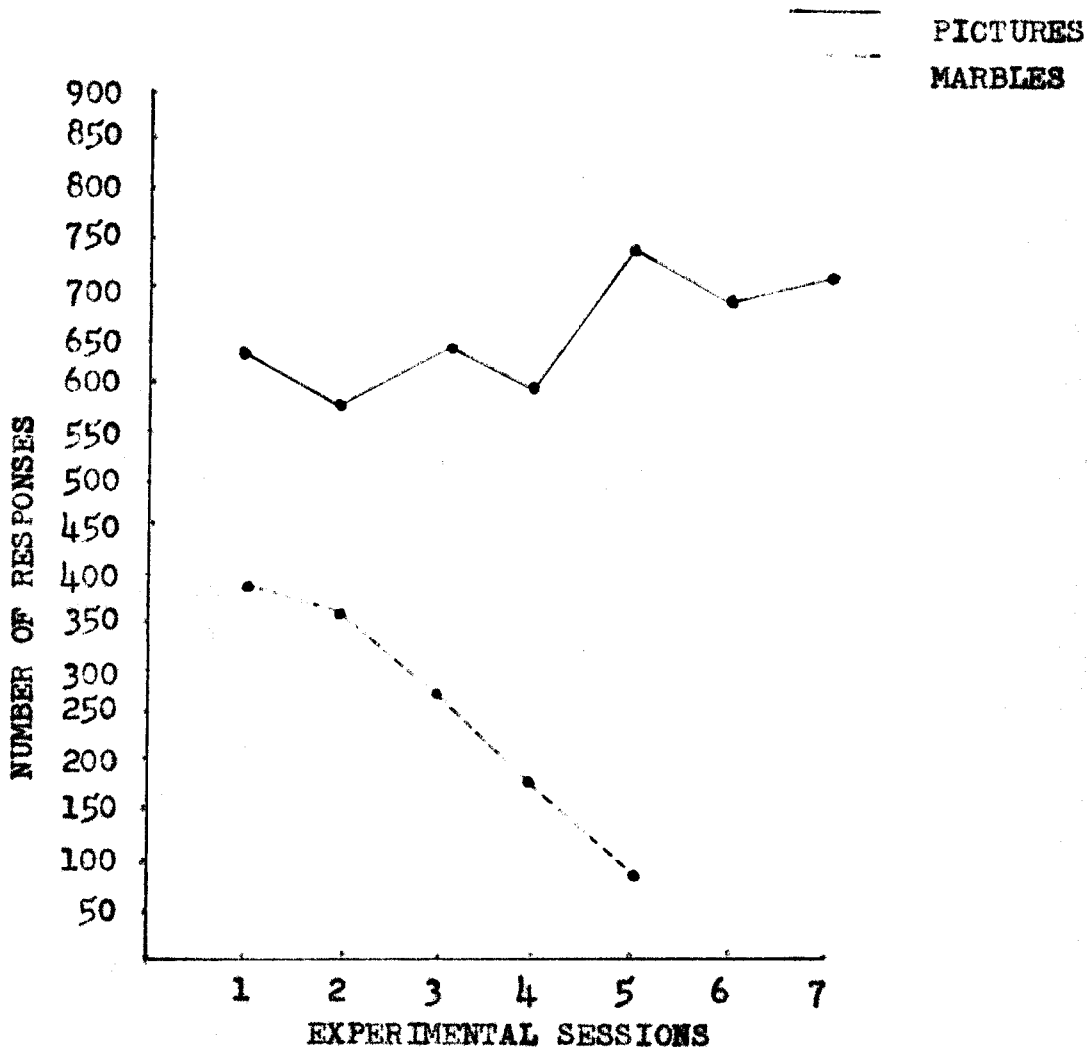


Fig. 40. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject G.

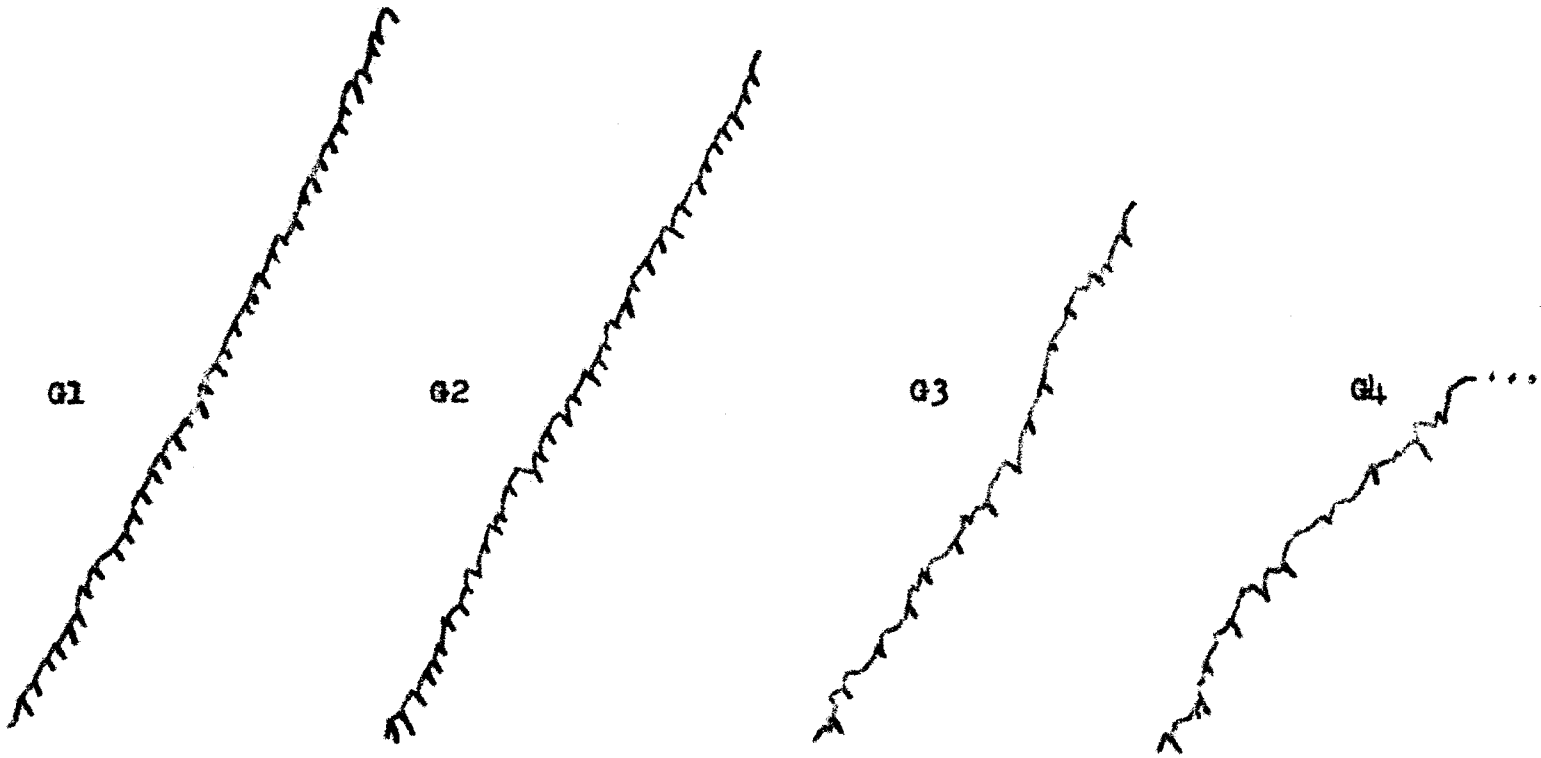
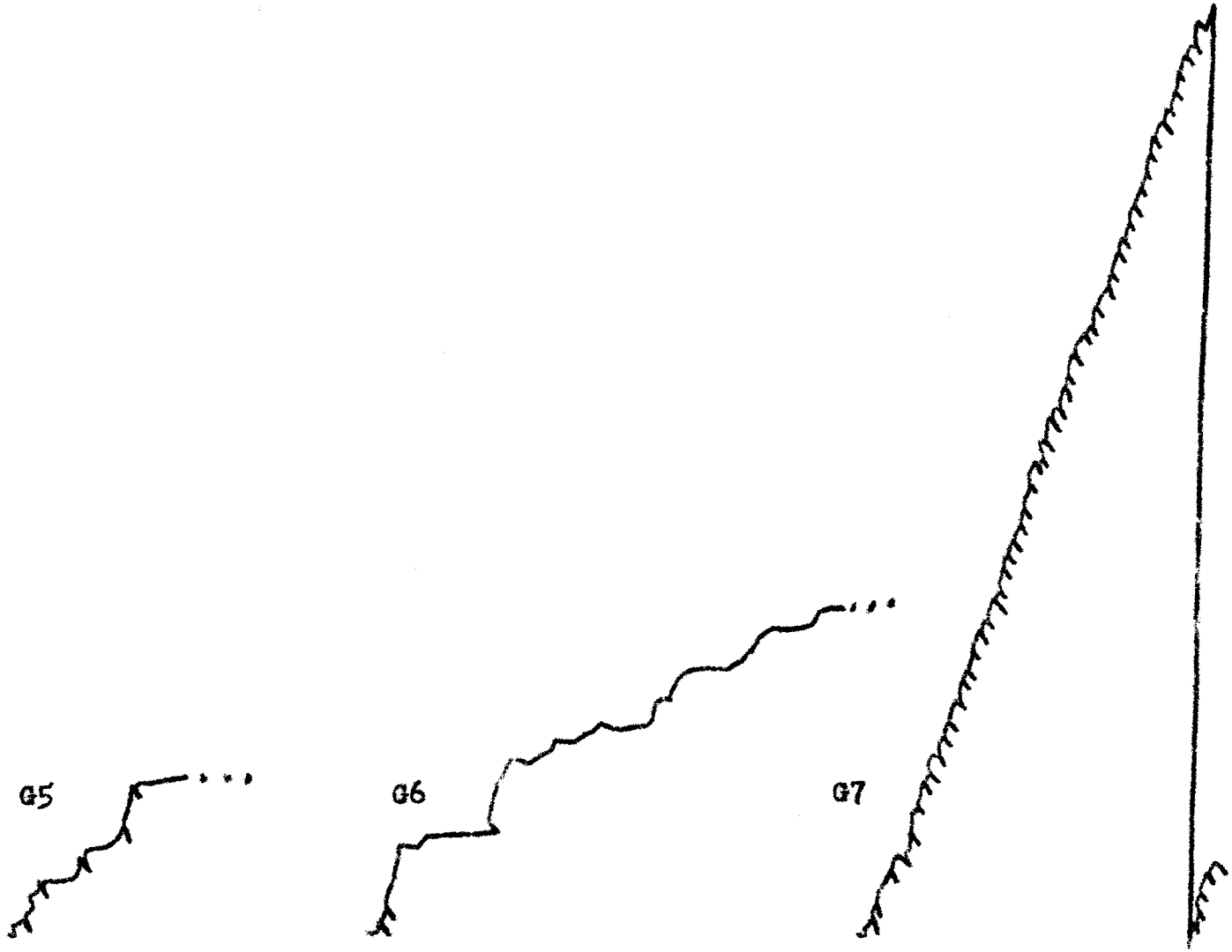


Fig. 41. Cumulative records, G1 through G4, for Subject G under the conditions noted.

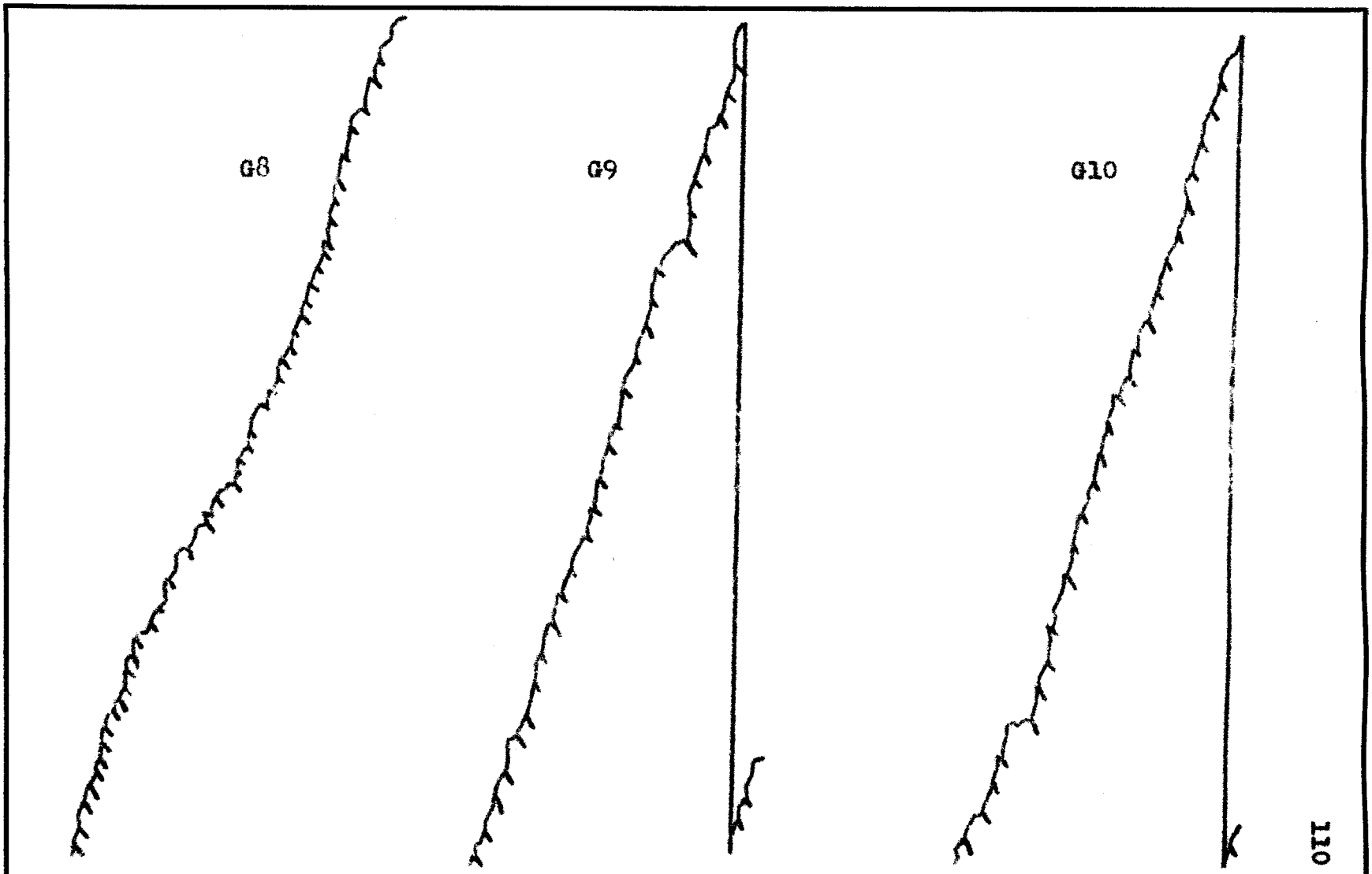


FR 20, MARBLES
RESPONSES - 88

EXTINCTION, MARBLES,
RESPONSES - 213

FR 10, PICTURES (ANIMAL)
RESPONSES - 633

Fig. 42. Cumulative records, G5 through G7, for Subject G under the conditions noted.

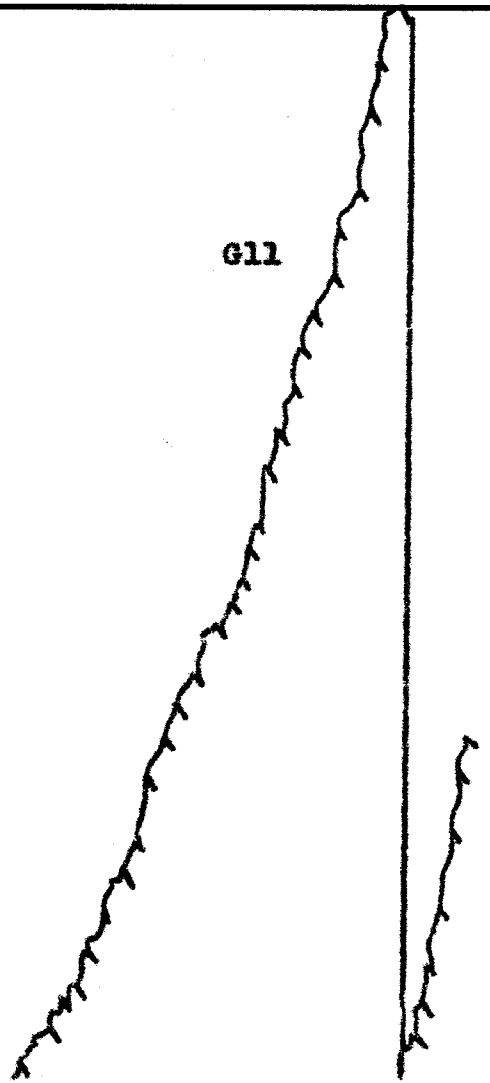


FR 10, PICTURES (ANIMAL)
RESPONSES - 563

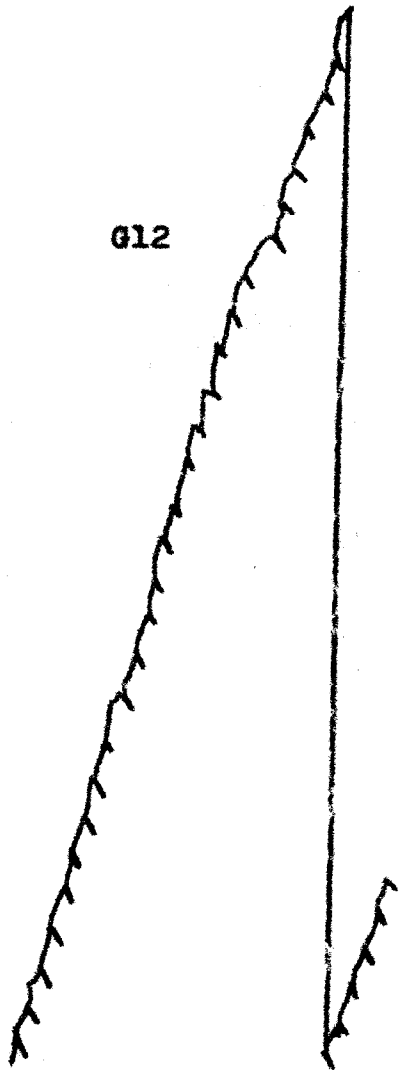
FR 20, PICTURES (ANIMAL)
RESPONSES - 641

FR 20, PICTURES (ANIMAL)
RESPONSES - 599

Fig. 43. Cumulative records, G8 through G10, for Subject G under the conditions noted.



FR 20, PICTURES (SELF-FAMILY)
RESPONSES - 749



FR 20, PICTURES (SELF-FAMILY)
RESPONSES - 684

Fig. 44. Cumulative records, G11 and G12, for Subject G under the conditions noted.

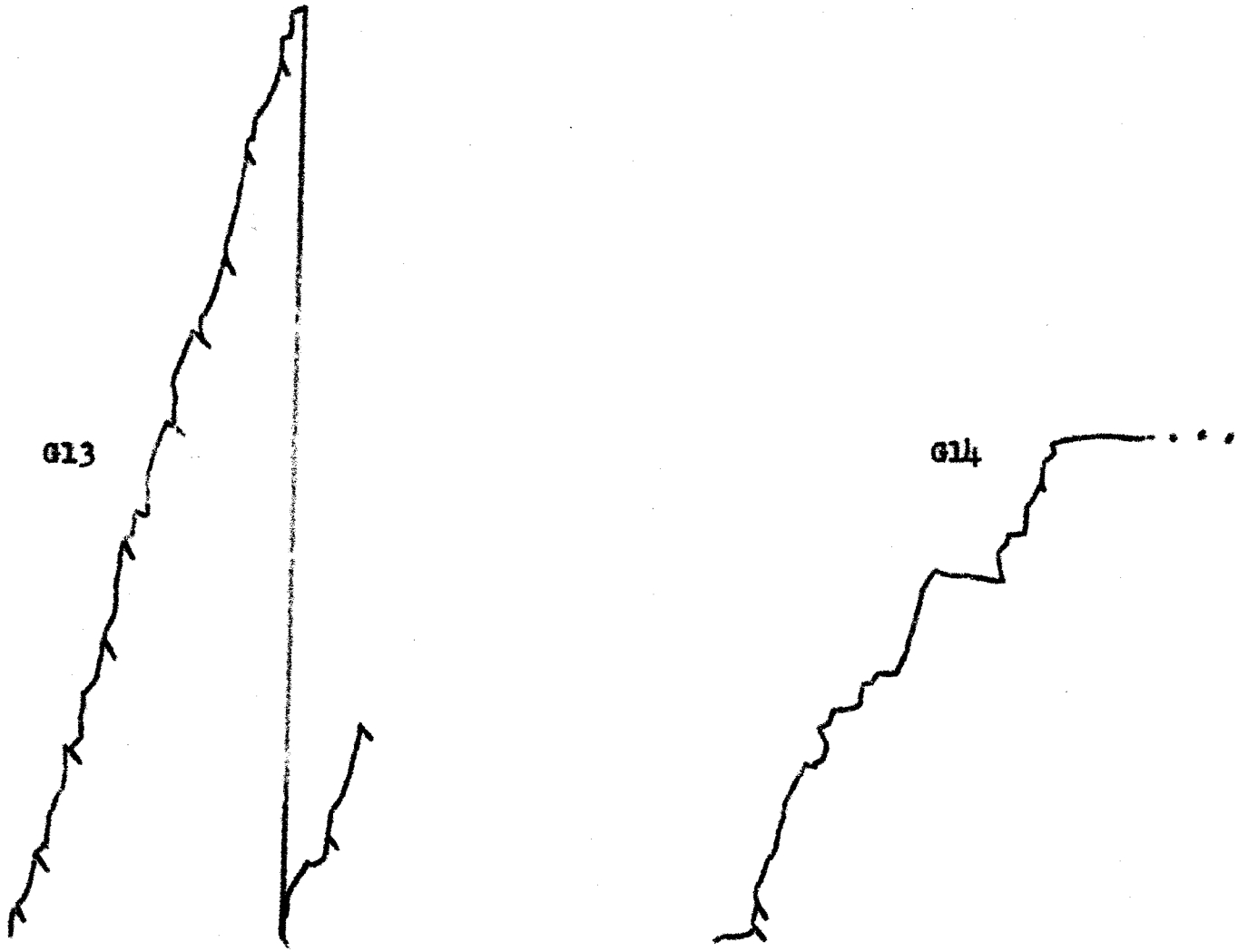


Fig. 45. Cumulative records, G13 and G14, for Subject G under the conditions noted.

sufficiently to proceed with the experiment. The incident was discussed with the mother and it was discovered that the subject had been brought to a hospital several weeks before. She had been taken to a playroom and a doctor had come in after a few minutes to give her an injection. Apparently, she associated the experimental room with the hospital playroom and the assistant in the white coat with the doctor.

Subject H gave 596 responses during this first session. Since this was the lowest number of responses given by this subject for picture reinforcers and well below her average number of responses it would seem safe to assume that her fear and anxiety had some affect on her response behavior during this first session. Even though the subject was fearful about the situation, her interest in the pictures was maintained at a high enough level to compare favorably with those first sessions of the other subjects. It might be added that the subject showed no fear or anxiety during any of the later experimental sessions.

Subject H was tested using pictures first and then marbles as reinforcers. She had the highest average number of responses per session (835) for pictures of any subject tested. She also had the highest single rate of response for one session (1049 or 104 responses per minute). She was able to do this because of a technique she learned that the others either did not learn or were not willing to employ. The stimulus picture remained on the

screen four seconds. The other subjects, for the most part, would stop pressing the bar when a picture was projected on the screen and then, when they could no longer see it, resume pressing. Subject H learned that she would receive reinforcing pictures much more quickly if she continued pressing the bar while viewing each picture. This technique was used during most of her sessions.

She responded at a significantly higher rate for pictures ($p < .001$), pressing the bar 70 per cent more than for marbles. Table 8 and Figure 46 indicate this subject's performance. Responses per minute, for marbles, varied from 10.4 to 34.1, and for pictures, from 59.6 to 104.9.

The individual analysis of records appears to indicate in this sample the superiority of pictures over marbles quite clearly. Most records made with marbles as a reinforcer are characterized by irregular responding and long pauses, neither of which indicates a durable, concentrated interest. The records made with pictures are characterized by rapid, steady responding, suggesting high and durable interest.

The following text is concerned with an analysis of the group used in the experiment. Table 9 provides a review of each subject's C.A., M.A., sex, and average number of responses for each reinforcer.

Table 8

Comparison Between Marbles and Pictures as Reinforcers in the Performance of Subject H

Number of Experimental Session	Marbles Used as Reinforcers		Pictures Used as Reinforcers		Percentage of the Difference in Number of Responses Between Marbles and Pictures
	Fixed Ratio Schedule	Number of Responses	Fixed Ratio Schedule	Number of Responses	
1	FR 10	341	FR 10	596	42.8
2	FR 10	326	FR 10	753	56.7
3	FR 20	249	FR 20	860	70.0
4	FR 20	214	FR 20	837	74.4
5	FR 20	104	FR 20	779	86.7
6			FR 20	1049	
7			FR 20	914	
8			FR 40	893	
Average		246.8		835.1	
Percentage of the Difference of Average Number of Responses Between Marbles and Pictures					70.4

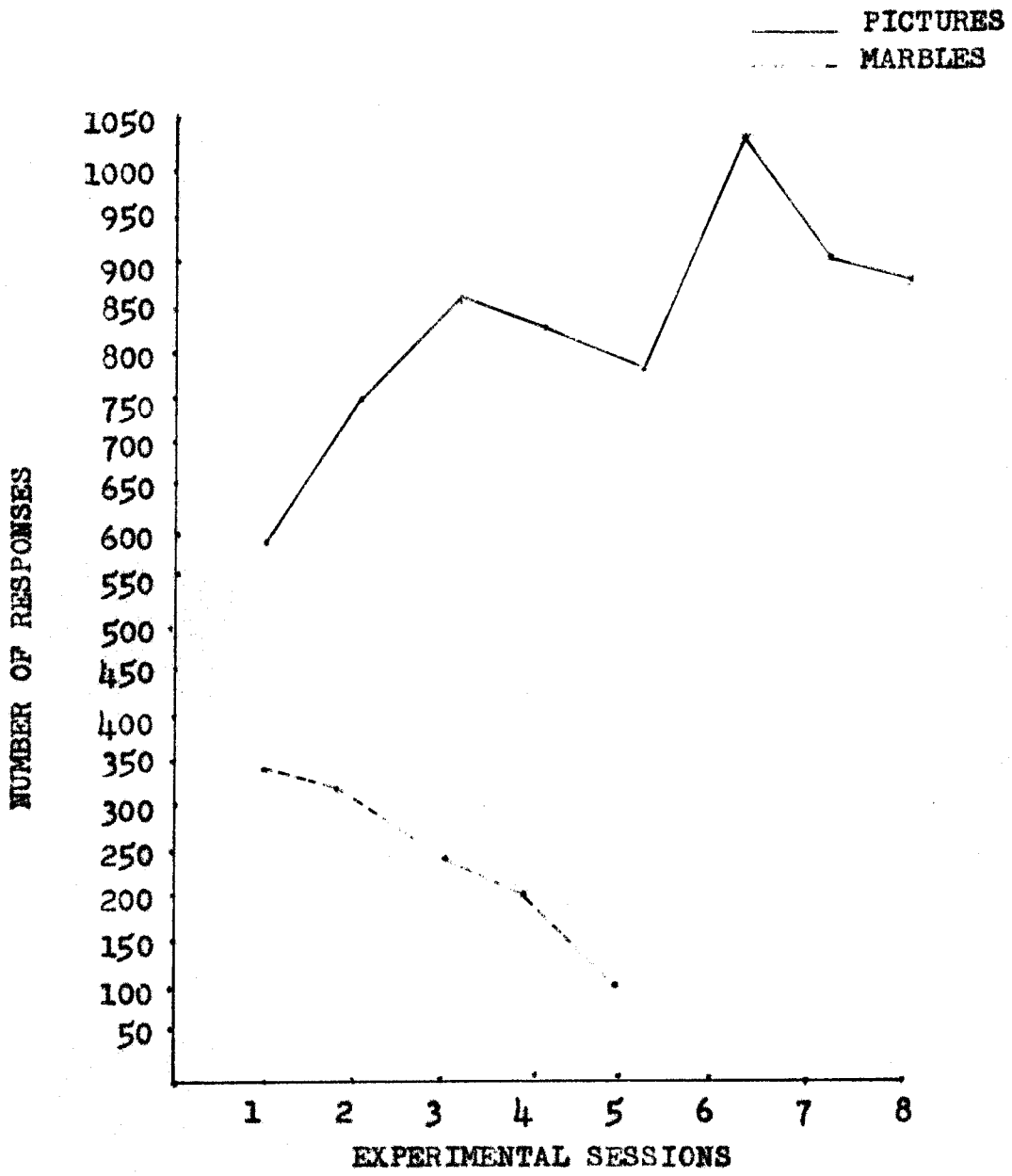


Fig. 46. Comparison between reinforcers in number of responses for each experimental session in the performance of Subject H.

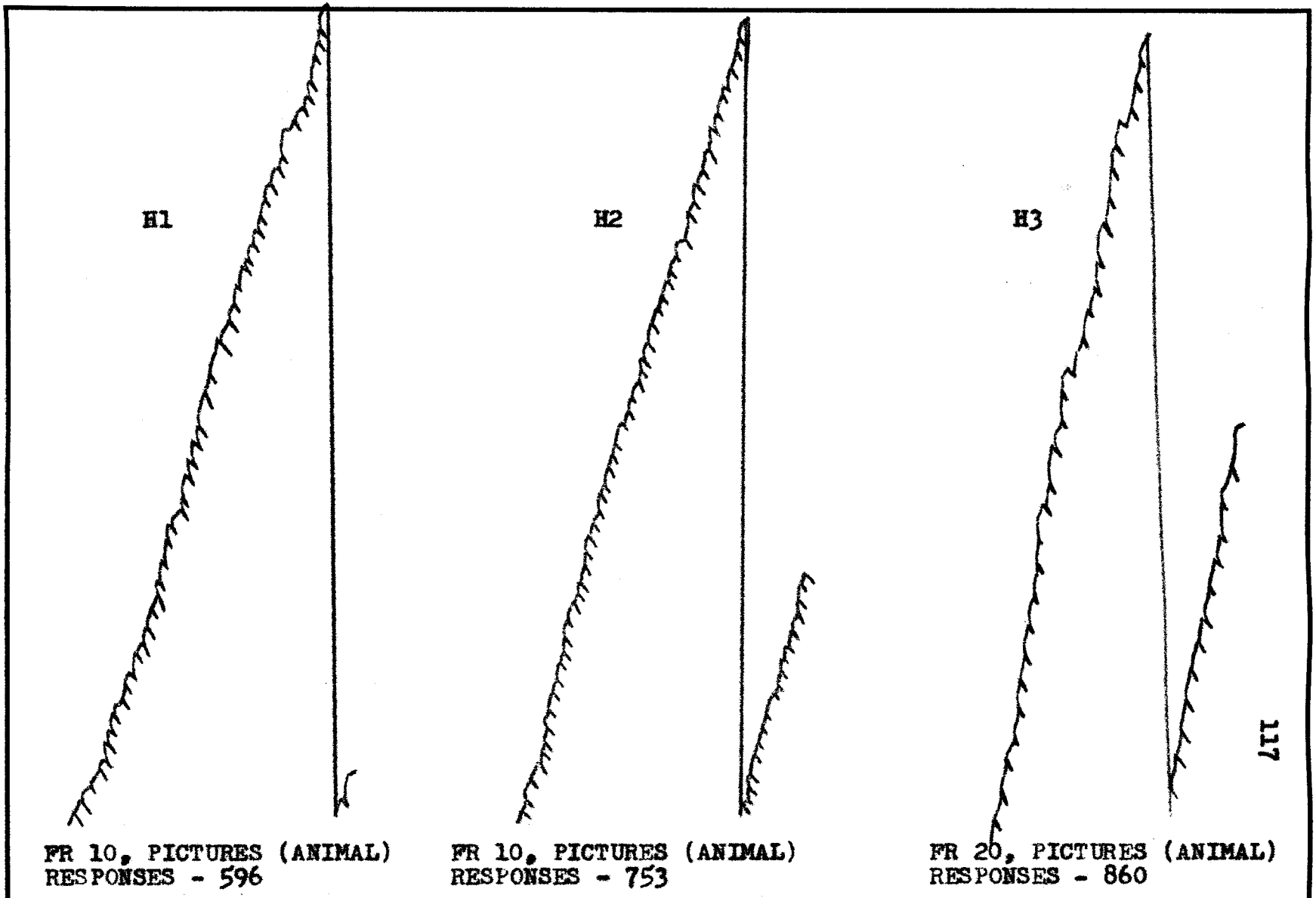


Fig. 47. Cumulative records, H1 through H3, for Subject H under the conditions noted.

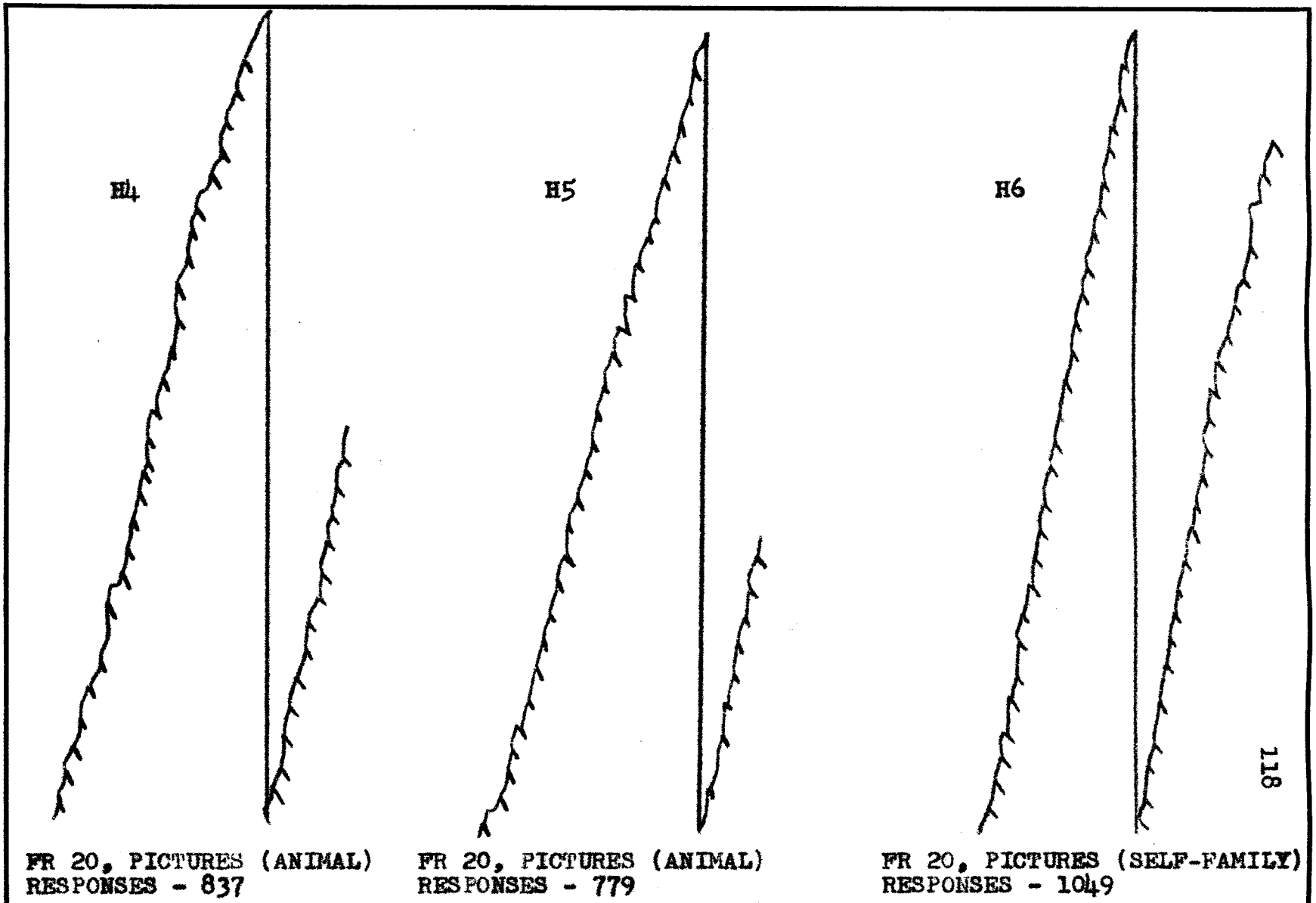


Fig. 48. Cumulative records, H4 through H6, for Subject H under the conditions noted.

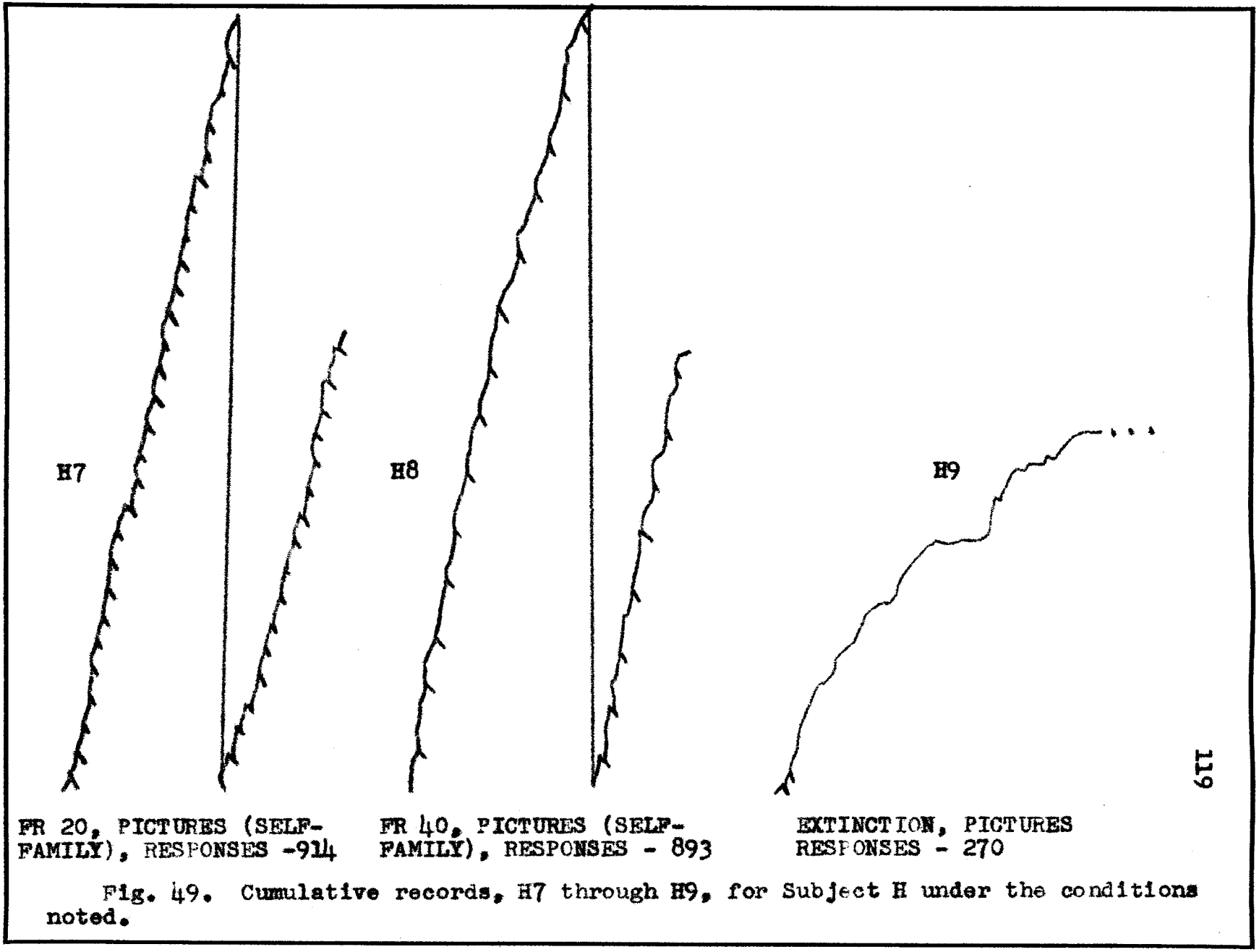
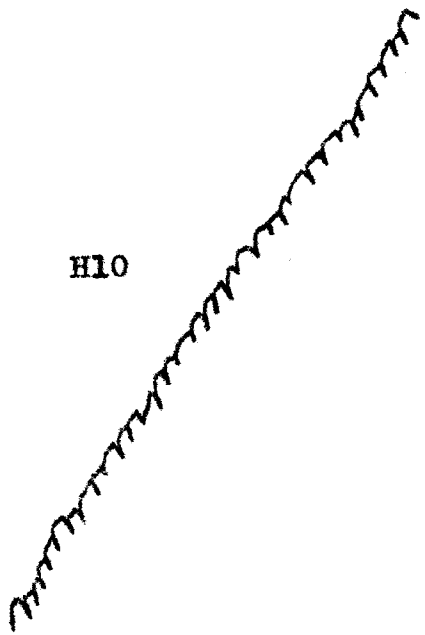
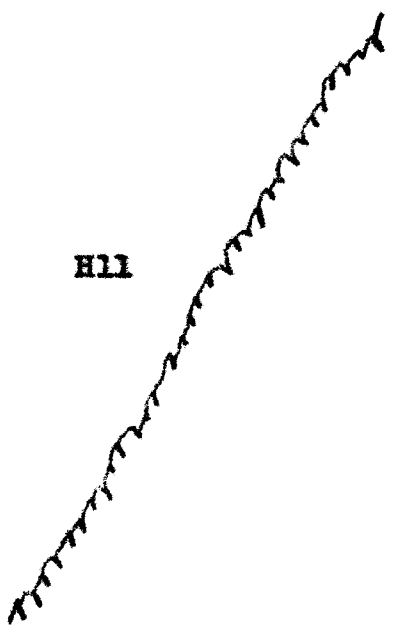


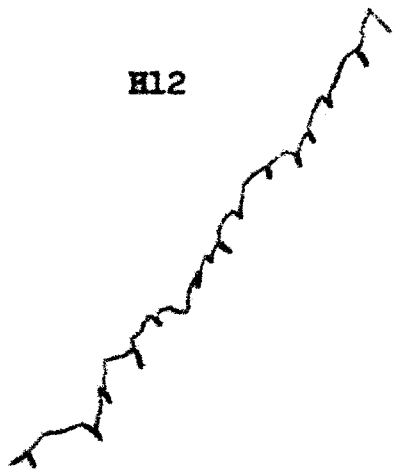
Fig. 49. Cumulative records, H7 through H9, for Subject H under the conditions noted.



FR 10, MARBLES
RESPONSES - 341

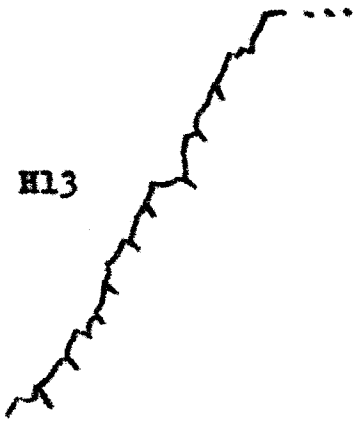


FR 10, MARBLES
RESPONSES - 326

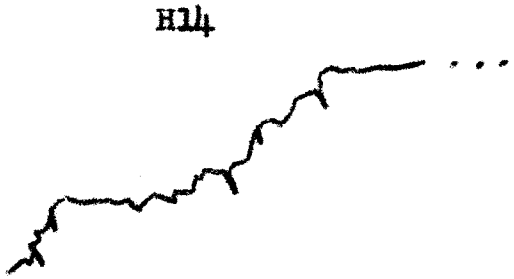


FR 20, MARBLES
RESPONSES - 249

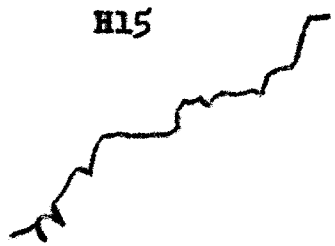
Fig. 50. Cumulative records, H10 through H12, for Subject H under the conditions noted.



FR 20, MARBLES
RESPONSES - 214



FR 20, MARBLES
RESPONSES - 104



EXTINCTION, MARBLES
RESPONSES - 116

Fig. 51. Cumulative records, H13 through H15, for Subject H under the conditions noted.

Table 9

Individual Performances of Sample Group

Subject	Sex	C.A.	M.A.	Average Number of Responses for Marbles	Average Number of Responses for Pictures
A	F	2-8	3-3	201.1	522.5
B	M	5-3	6-3	428.6	597.2
C	M	4-0	3-10	299	490
D	F	4-5	4-4	250.5	665.6
E	F	6-3	3-8	171.1	447.5
F	M	9-7	5-9	364.4	672.2
G	M	6-5	3-7	254.5	608.8
H	F	7-3	4-0	225	772.3

The eight subjects gave a total of 57,332 responses in 124 experimental sessions. For the 52 sessions using marbles as reinforcers, 14,161 responses were given. This is an average of 272 responses per session. For the 72 sessions using pictures as reinforcers, 43,171 responses were given. This is an average of 499 responses per session which is more than twice the average number given for marbles. The normal children as a group appeared to have a slightly higher interest in marbles and a slightly lower interest in pictures than the retarded children.

Table 10 illustrates the sustained interest which pictures represented over marbles on the extinction trials. Each trial was

begun by giving two reinforcements on FR 10. No further reinforcement was given. The child remained in the experimental room for ten minutes but on several occasions no responses were registered for the last few minutes.

The group as a whole made over 40 per cent responses when they expected pictures as reinforcers than when they expected marbles. This was true even though every subject had more exposure to pictures due to the fact that they satiated rapidly when marbles were used. It is felt that this difference in response is one of the strongest indicators of the durable interest shown in picture reinforcers.

Table 10

Comparison of Reinforcers on Extinction Trials

Subject	Number of Responses on Extinction Trial Using Marbles	Number of Responses on Extinction Trial Using Pictures	Per Cent Increase in Responses
A	97	252	62
B	243	354	31.4
C	128	216	40.8
D	191	376	49.3
E	103	217	52.6
F	296	359	17.6
G	213	294	27.6
H	116	270	57.1
Total	1387	2338	40.7

Table 11 indicates the individual and group differences with regard to the average number of responses made per minute. All eight children, with pictures as reinforcers, made responses averaging close to 60 per minute. Three retarded and one normal child exceeded one response per second for all trials using pictures. The group averaged 59.6 responses per minute for pictures and 27.4 responses per minute for marbles. The subjects as a group, therefore, responded an average of 54 per cent faster for pictures than for marbles.

Table 11

Average Number of Responses Per Minute for Marbles and Picture Reinforcers

Subject	Marbles	Pictures
A	20.1	52.2
B	42.8	59.7
C	29.9	49.0
D	25	66.5
E	17.1	44.7
F	36.4	67.2
G	25.4	60.8
H	22.5	77.2
Average	27.4	59.6
Percentage of the Difference in Average Number of Responses Between Marbles and Pictures		54.1

The study of the relationship between mental age and rate of response for each of the reinforcers was determined by applying the formula for the Spearman rank coefficient of correlation. A positive correlation of .63 was obtained comparing mental age with average number of responses for all sessions using marbles as reinforcers. A sample of 8 requires a correlation of .643 to reach the .05 level of confidence. Therefore, in this sample, mental age does not correlate significantly with rate of response. However, a correlation of .63 is close enough to the .05 level of confidence to suggest that children with higher mental ages would tend to have more interest in marbles.

A positive correlation of .45 was obtained comparing the experimental group's mental ages with average number of responses for all sessions using pictures as reinforcers. According to this finding, mental age is not significantly related to rate of response for pictures.

Several conclusions may be drawn tentatively from the findings presented above. It appears that mental age is somewhat more likely to have an effect on the number of responses when marbles are used as reinforcers. Pictures are less likely to have this effect. A good reinforcer needs to be versatile and applicable to large samples. Therefore, a reinforcer is acceptable even though it lacks a fine discrimination for mental age so long as it consistently elicits a high rate of interest.

The sample presented here is too small to make general conclusions. However, the trend shown indicates that less attention may have to be given to the mental ages of a sample of young children if pictures rather than marbles were used as reinforcers.

Ellis (9) found in his studies that the number of responses did increase significantly with mental age. However, his sample was composed of children and adults, C.A. 15 to 38. The findings presented here do not agree with his results but may not be comparable due to the differences in chronological age and also due to the fact that a different reinforcer, M and M candy, was used.

A rank correlation was also computed comparing I.Q. and rate of response for pictures. The result was not significant and this finding compares favorably with the results of Mednick and Lindsley (19) who found rate of response and I.Q. to be unrelated. The previously reported correlation of .45 between M.A. and rate of response is due in large part to the closely related mental ages within the group. Six of the eight subjects had mental ages from 3-3 to 4-0 so a fine discrimination between them is not possible. The I.Q.'s ranged from 57 to 123. Also the child with the lowest M.A. had the highest I.Q. (Subject A, C.A. 2-8, M.A. 3-3, I.Q. 123).

Perhaps the most interesting result in the study was that three of the four retarded children exceeded the average number

of responses for pictures made by the normal group. Also, it was a retarded child who had the highest average response rate (835) and the highest rate for a single session (1049). However, since the retarded group's life experience has been longer than that of the normal group they might tend to do somewhat better on tasks which are concrete.

It was hypothesized in Chapter I that a reinforcer, such as pictures, which maintained a consistently high level of interest would elicit a significantly better performance than some other reinforcer reported extensively in the literature. In the sample reported, the results suggest that pictures have a significant advantage over marbles. If the trend indicated in this study is maintained in later experimentation, pictures may prove ideally suited for work with both normal and mentally deficient young children.

Chapter VI

Summary and Conclusions

The primary purpose of the present study has been to find a suitable reinforcer for use with young children which demonstrates versatility and minimal satiation effects. It was hypothesized that any reinforcer having these characteristics would show a significant superiority in eliciting performance when compared with a reinforcer extensively used by other experimenters.

A secondary purpose has been to investigate the operant conditioning technique developed by Skinner and others as a means of observing and analyzing the behavior of normal and retarded children.

A review of the literature revealed several studies directly concerned with human conditioning and with the problem of reinforcers. Skinner (22) began this work in 1954 and used pictures as reinforcers with psychotics. He also used candy and cigarettes. Ferster (11) reported using pictures as reinforcers with autistic children but did not report any details concerning them. Bijou (2, 3) reports studies with children using a marble dropping device and several other reinforcers, but reported large satiation effects. Long, Hammack, May and Campbell (17) and Long (18) also reported using pictures in conjunction with other

reinforcers, but no details were given about them. A large part of the literature appeared to be aimed more toward exploratory study than practical results. The search for durable reinforcers was a prime consideration in these studies. Unpublished work reported by personal communication appeared to be aimed more toward achieving some practical results but experimenters still reported concern over the problem of finding more stable reinforcers.

In the present study, eight children, four normal and four retarded, were tested using two reinforcers, marbles and pictures. The research was designed to discover which type would most facilitate controlled behavior appropriate to extended research. Each child was tested individually using one reinforcer until the cumulative records showed either satiation or continued high interest rate. Then the other reinforcer was used until the records showed one of these conditions. Each child's responses were individually analyzed. The responses of the group as a whole were also studied.

Each child showed a highly significant preference for pictures of animals over marbles as a reinforcer. Pictures of the child, his family and favorite toys produced a more pronounced preference. Four children approached the average level of one response per second and four children exceeded an average of one response per second for all sessions using pictures.

Extinction sessions substantiated the above findings in

accord with general laws of operant conditioning. The eight children as a group pressed the bar 40 per cent more without receiving any reinforcement when they were expecting pictures than when they were expecting marbles. Individually, they responded from 17 per cent to 62 per cent more. There were also qualitative differences during the extinction periods; the subjects did not appear to be as irritated during the marble extinction periods. They wandered about the room exploring, occasionally going back to the bar to press it. During the picture extinction periods they often hit the bar in anger and two children shouted for the experimenter to "fix it".

During the experimental sessions, 57,332 responses were recorded with all eight subjects. The group gave 54 per cent more responses during these sessions for pictures than for marbles.

It was found that there was no significant relationship between mental age and rate of response, and I.Q. and rate of responses, although the small sample does not allow general conclusions to be made. These findings disagree with one investigator, Ellis (9), but may not be comparable due to wide differences between the two studies regarding age of subjects and reinforcers used.

The retarded children as a group exceeded the normal children in rate of response, but not to any significant degree. It would not have been possible to predict rate of response by

the fact that a child had either an I.Q. within the normal range or below 60. The fact that retarded children may perform willingly and actively on the operant conditioning tasks presented in this study suggests that the technique may be suited for further work with this clinical type. From the results it may be concluded that the proposed hypothesis has been established.

There are many more variables in working with children than may be apparent. One of the early sessions (Subject A, A9, Page 61) was begun by placing the subject on a stool with a revolving seat. The frequent pausing was a result of the fascination this seat had for the child. A stool with a non-movable seat was used for subsequent sessions and record A10 illustrates the improved performance.

The incident with Subject H has already been discussed. Her fear and anxiety appeared to have influenced her first session (H1) since the result was considerably below her general average for all sessions.

Other variables were more difficult to control. Additional "rewards" for the child included rides to and from the behavior laboratory and a considerable amount of individual attention.

The important finding in this experiment is not that picture reinforcers work better than do marble reinforcers. It is that pictures work substantially better. It may be possible to find one reinforcer which produces more responding than another and still not maintain the durable interest necessary for extended

research. The differences between pictures and marbles are not wholly statistical. The records made using pictures as reinforcers are highly consistent and regular showing a strong, steady interest; while those using marbles are erratic and inconsistent.

Some advantages and disadvantages of using the general method described in this study follow:

Disadvantages:

1. The method is apt to test the patience of investigators used to less sensitive measures and to quick parametric studies. If it is desired to correlate the results with another measure that depends on a very large "N" for its reliability, the free operant method probably should not be used since it would take too long to generate the large sample demanded.

2. Equipment is expensive and requires at least fundamental knowledge of electrical systems and circuitry.

3. Considerable space (free of other activity) is required for the equipment and experimental room.

Advantages of Method:

1. High experimental control: the exclusion of unwanted variables produces more stable behavior and higher sensitivity. The simplicity of design makes for analytical and interpretive ease.

2. Automatic recording and scheduling: since the behavior is automatically recorded, no problems of experimenter bias and

error are involved in the collection of the raw data. Permanent, continuous records are available for later analysis and interpretation. Presumably any two experimenters in any two laboratories should be able to collect similar records just by arranging the appropriate experimental conditions.

3. Minimal instructions: The method permits the investigation of the behavior of children who do not communicate verbally.

The following additional conclusions seem indicated from the results of this experimentation:

1. Responding which was reinforced with pictures on FR schedules resembles that reported for other organisms reinforced with homeostatic rewards.

2. First-session FR schedules of less than 10 frequently produce a deceleration of overall rate which is characterized principally by increases in length of pausing after reinforcement.

3. The performance of all subjects underwent deterioration as the number of sessions increased when marbles were used as reinforcers.

4. Pictures as reinforcers produced largely stable, smooth, and linear performances. There was no significant deterioration as the number of sessions increased or as the fixed ratio was raised.

5. Fixed ratio schedules, in general, were found to exercise considerable control over performance.

6. Higher ratios serve to increase the number of responses where interest is high and decrease the number of responses where interest is low.

7. There appears to be no significant relationship between I.Q. or mental age and rate of response although the sample is too small for a general conclusion to be made.

8. According to the sample used, retarded children could be expected to perform as well as normal children of the same mental age on the concrete task presented in this study.

Future Research Possibilities:

1. Trainability Index. It is possible that rate of response may have some relationship to the trainability of retarded children as it does toward behavior of psychotics according to Lindsley (15). Subject E, for example, had poor language development and was withdrawn. She had the poorest response rate of the four retarded children. Subject H, within four months of Subject E's mental age, could speak fairly well and was more socially mature. She had a very high rate of response. It is, of course, impossible with this sample to do more than suggest a possible trend. There are many variables which may have influenced individual behavior.

2. Pictures may be adaptable to studies of personality patterns or family relationships. A simple example might consist of two bars and two translucent screens, one showing pictures of

the mother and the other showing pictures of the father. It would be interesting to study the rate of response for each.

3. It may be possible to use pictures as reinforcers for teaching academic material such as numbers, or letters of the alphabet, or even for teaching acceptable social behavior.

4. Using pictures may mean that the experimenter can work without necessarily requiring the elaborate and highly expensive equipment such as that developed by Ferster (11).

Although more than 57,000 responses were recorded to date, it is not suggested that the records of a group of eight children can be used to state general conclusions. It has been shown, however, that the technique and reinforcer described can be used equally well with normal and retarded children. Also this small group presents an individually unblemished trend which suggests that the same trend may develop with larger samples.

Bibliography

1. Azrin, N. H. and Lindsley, O. R. The reinforcement of cooperation between children. J. abnorm. soc. Psychol., 1956, 52, 100-102.

2. Bijou, S. W. Methodology for an experimental analysis of Children. Psychol. Reports, 1957, 3, 243-250.

3. Bijou, S. W. A systematic approach to an experimental analysis of young children. Child Develpm., 26, 1955, 161-168.

4. Bijou, S. W. Learning in Children. Child Develpm., 1959, 24, 25-36.

5. Bijou, S. W. and Sturges, P. T. Positive reinforcers for experimental studies with children--comsumables and manipulatables. Child Develpm., 1959, 30, 151-170.

6. Bijou, S. W. Patterns of reinforcement and resistance to extinction in young children. Child Develpm., 28, 1957, 47-54.

7. Bijou, S. W. Operant Extinction after FI schedules with young children. J. exper. anal. Behav., 1958, 1, 25-29.

8. Bijou, S. W. Discrimination performance as a baseline for individual analysis of young children. Child Develpm., in press.

9. Ellis, N. R., Barnett, C. D. and Pryer, M. W. Behavioral Studies in Mental Deficiency. Dept. of Psychol. State Colony and Training School, Pineville, La. Chapter VII--"Operant Behavior in Mental Deficiency"--Exploratory Studies, June, 1958 to May, 1959, 72-77.

10. Ferster, C. B. and B. F. Skinner. Schedules of Reinforcement. New York, Appleton-Century-Crofts, Inc., 1957.

11. Ferster, C. B. and DeMeyer, M.K. The Development of performance in schizophrenic children in an automatically controlled environment. Unpublished Report, Indiana U. Medical Center.

12. Hilgard, E. R. Theories of Learning. Appleton-Century-Crofts, 1956.

13. Lawson, Reed. Learning and Behavior. The Macmillan Co., 1960.

14. Lindsley, O. R. Progress Report I--An Experimental Analysis of Psychotic Behavior. Nat'l Institute of Mental Health, Dec., 1954--June, 1956.

15. Lindsley, O. R. Operant conditioning methods applied to research in chronic schizophrenia. Psychiatric Research Reports 5. Am. Psychiatric Ass'n, June, 1956.

16. Lindsley, O. R. Annual Tech. Report 3. New Techniques of Analysis of Psychotic Behavior. Office of Naval Research, U.S. Navy, Sept., 1955-Nov., 1956.

17. Long, E. R., Hammack, F. M., Campbell, B. J. Intermittent reinforcement of operant behavior in children, J. exper. anal. Behav., 1, 315-339.

18. Long, E. R. The use of operant conditioning techniques in children. Child Research in Psychopharmacology, 1959, 111-136.

19. Mednick, M. T., and Lindsley, O. R. Some clinical correlates of operant behavior. J. abn. soc. Psychol., 1958, 57, 13-16.

20. Orlando, R. A discrimination reversal test of Estes' model for competing reactions. Unpublished doctoral dissertation, U. of Connecticut, 1958.

21. Orlando, R. Experimental analysis of retarded behavior. Report of research from June, 1958, to Jan., 1960. Personal communication, 1960.

22. Skinner, B. F. A new method for the experimental analysis of the behavior of psychotic patients. J. of Nervous and Mental Disease, 1954, 120, 403-406.

23. Skinner, B. F. Science and Human Behavior. New York, Macmillan, 1953.

24. Skinner, B. F. The Cumulative Record. Appleton-Century-Crofts, 1959.

25. Skinner, B. F. The Behavior of Organisms. New York: Appleton-Century-Crofts, 1938.

APPROVAL SHEET

The dissertation submitted by Frank A. Dinello has been read and approved by a board of five members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content, form, and mechanical accuracy.

The dissertation is therefore accepted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

Oct 20, 1960
Date

Frank J. Kobler
Signature of Adviser